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BAYER LEVERKUSEN (GERMANY)

Department for Plant Protection

A Contribution to the Question of the Resistance of *Tilletia tritici* to Mercury

By A. Winkelmann and H. L. Paul
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For the past twenty years and more, complaints have been raised time and time again concerning the poor efficacy of mercury steeps against stinking smut in wheat. The reasons for the significance of this disease have been investigated without any definite result being obtained. In recent years it has been established, with respect to the application of insecticides, that when one and the same active ingredient is repeatedly used, it is possible for species to develop which after a time are no longer sensitive to these particular substances. Therefore, there was a tendency to assume that even with stinking smut, species had come into being which are also resistant to steeps containing mercury. As far back as 1935, Winkelmann had pointed out the possibility of species occurring which are resistant to mercury. For a number of years he carried out field tests to determine whether the constant application of mercury-containing steeps would lead to the formation of resistant species. In these tests the seed was infected

Table 1 The spore material

Spore variety	Location where it was found	Infested wheat variety at locations given
I	Munich	"Mauerner begrannter Dickkopf"
II	Munich	"Tyssilo"
III	Stuttgart	variety unknown
IV	Münster	"Strubes Dickkopf"
V	Bonn	"Carstens V"
VI	Herford	variety unknown
VII	Hanover	variety unknown
VIII	Unna	variety unknown
IX	Brilon	variety unknown
X	Eversberg	variety unknown
XI	Wehrstapel/Meschede	variety unknown
XII	Brakel, Krs. Höxter	variety unknown

with different spore varieties, and from the treated plots infested spikes were gathered to be used for the following vegetation period, although there was never any indication that resistant species were included. However, in view of the fact that many continued to suspect that such types would be formed, several spores of stinking smut were taken from various parts of West and South Germany and subjected to a renewed test. The material selected was mostly from heavily infested fields, and particularly that on which the steeps were said to have had no effect.

The spore variety IV had already been used for a number of years in Münster for the purpose of testing steeps, and the effect obtained with it had never been other than satisfactory. The tests were carried out in 1950/51 and 1951/52. The artificial infection was carried out along the lines of the methods employed for testing steeps, at the rate of 2 g per 1 kg. Wherever naturally infected seed was available, the degree of infection was determined by the following method:

Equal quantities (7 g) of infested wheat were thoroughly shaken and washed twice in two vessels containing 25 ccs of 96 % alcohol so that when the grains were closely examined no more spore residues could be detected. After the spores had been centrifuged off, they were again soaked in several cubic centimetres of alcohol, and placed in glass tubes of medium thickness to deposit. The level of sedimentation was marked off. Due to a dissimilarity of the tubes, the levels could not be taken as a standard, and instead the volume occupied by the spores was weighed (tubes dry, empty, tubes filled up to the mark with *Aqua destillata)* and recorded as the standard of comparison. The values obtained with artificialy infected seed served as the reference standard.

The degree of infection for spores VI and VIII was high. It could not be determined for spore variety IX since the material had been used up in the field tests, although the rate was higher than 2 g per 1 kg. The wheat variety "Strubes Dickkopf Winterweizen" (winter wheat) was infested artificially. In the naturally infested seed, the varietises could not be established with certainty.

Alkoxyalkyl-Hg compounds were used as dry dressing A and as wet dessings D and E, alkyl-Hg compounds used as dry dressing B and wet dressing F, and a mercury-free, organic compound as dry dressing C. The tests

Table 3 Results of field tests carried out in 19

Seed dressing	Application	Spore I			Spore II			Spore IV		
		Muenster % Infestation	Munich % Infestation	Leverkusen % Infestation	Muenster % Infestation	Munich % Infestation	Leverkusen % Infestation	Muenster % Infestation	Munich % Infestation	%
untreated	—	33·0	39·1	40·15	27·5	36·9	38·72	38·6	30·4	
A	150 g/100 kg	0·2	0·8	0·05	0·6	0·2	0·0	0·85	0·1	
	200 g/100 kg	0·0	0·9	0·0	0·46	0·2	0·06	0·0	0·0	
E	0·1 %—30' T	0·1	0·0	0·0	0·0	0·0	0·0	0·1	0·0	

Wheat varieties I — V and VII: "Strubes Dick

Table 2 Results of field tests

Seed dressing	Application	Spore I % infestation	Spore II % infestation	Spore III % infestation	Spore IV % infestation	Spore V % infestation	Spore VI % infestation	Spore VII % infestation	Spore VIII % infestation	Spore IX % infestation
untreated	—	8·7	24·0	33·0	31·0	31·0	39·0	7·0	16·0	12·0
A	75 g/100 kg	1·0	4·0	0·6	2·5	0·6	30·0	1·7	8·0	1·9
	100 g/100 kg	0·0	1·3	0·0	0·2	0·0	14·0	0·0	6·6	1·8
	150 g/100 kg	0·0	0·0	0·0	0·0	0·0	11·0	0·0	0·7	0·0
B	75 g/100 kg	0·0	0·4	0·4	0·4	0·0	15·0	1·1	2·5	0·5
	100 g/100 kg	0·0	0·0	0·0	0·0	0·0	3·3	0·0	1·5	2·9
	150 g/100 kg	0·0	0·0	0·2	0·0	0·0	4·8	0·0	0·0	0·0
D	0·05%—30'T	0·0	0·0	0·0	0·0	0·0	5·2	0·0	0·0	0·0
	0·1% —30'T	0·6	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
E	0·05%—30'T	0·0	0·0	0·0	1·1	0·4	3·5	0·4	2·7	0·0
	0·1% —30'T	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
F	0·05%—15'T	0·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
	0·1% —15'T	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0

Wheat varieties I – V and VII: "Strubes Dickkopf"
Wheat varieties VI, VIII, IX: unknown
Date of sowing: Nov. 6, 1950
Type of soil: sandy loam
Weather on date of sowing: + 5° C, damp
Humidity of soil: 17·2%
Previous crop: Beet

Muenster, Munich and Leverkusen

Seed ressing	Application	Spore V			Spore VI			Spore VII		
		Muenster % Infestation	Munich % Infestation	Leverkusen % Infestation	Muenster % Infestation	Munich % Infestation	Leverkusen % Infestation	Muenster % Infestation	Munich % Infestation	Leverkusen % Infestation
treated	—	41·5	42·8	28·08	46·0	51·6	51·0	44·0	34·9	35·58
A	150 g/100 kg	0·0	0·0	0·0	11·5	2·8	1·61	0·0	0·4	0·21
	200 g/100 kg	0·55	0·2	0·0	9·0	2·3	0·99	0·0	0·4	0·04
E	0·1%—30'T	0·0	0·2	0·0	0·5	0·9	0·39	0·0	0·1	0·05

heat variety VI: unknown

were arranged on the same lines as those followed for testing steeps. According to the results reproduced in Table 2, the effect of the steep applied in the standard concentrations and at the usual rates was quite satisfactory, with the exception of spore variety VI. It should, however, be pointed out that the degree of infection in this particular variety was higher than with artificial infection. Also in the case of spore variety VIII the heavy infection was most discernible.

The considerable influence that can be exerted by external factors upon dressing is best illustrated by Table 3 which represents an extract from a large test series. Here large quantities of the seed had been dressed in Münster and sent to the other research organisers. Considerable deviations resulted which undoubtedly must have been due to external conditions. The results obtained in these tests are particularly striking with spore variety VI. The explanation of this has already been given above. The tests carried out in 1951/52 in particular with spore varieties which had still shown heavy infection even after the treatment in 1950/51, in no way confirmed that the varieties were resistant to mercury (Table 4). The opinion often expressed that the infection could be largely reduced by pure washing off was not corroborated. Treatment with water did not reduce the infection to any great extent either.

In single cases the tests carried out on two experimental fields situated quite close to each other showed really large differences in infection, particularly with low concentrations and low rates of application. The influence the degree of infection had upon the infestation and upon the effect of the steep may be seen from the test results reproduced in Table 6. All the dry dressings used failed completely.

Since there is a widespread tendency to assume that the varieties exert a considerable influence upon the effect of the dressing agent, tests were carried out on two different experimental fields with three varieties of wheat and two spore types but nothing was established to show that any influence is exerted by the wheat varieties (Table 5).

On summarizing the results of the field tests for both years, there is no indication that certain spore types offer greater resistance than others. However, it can definitely be said that the individual steeps differ in their mode of action, a fact established by Gassner on several occasions. Steep C was most effective in our tests, although as an Hg-free dressing it can only be used on wheat, and even with this crop it does not prevent the occurrence of mould. An important factor for the efficacy is the degree of infection. When high infections are encountered, which is only too often the case in the field as the tests show, the effect of all dressing agents recedes considerably. Either a part is played in this by the rates of absorption or a clot occurs with dry dressing agents due to the presence of the large quantities of spores, the latter possibility having already been proved in the past by Winkelmann.

In confirmation of the field tests, the influence of steeps on the spores was examined in comprehensive laboratory experiments, the main purpose being to establish whether there are in general any differences between the spores with respect to the germination ratio. A nutrient substratum made up of 2 % agar and 0·25 % calcium nitrate was used as the germination medium. The dishes were placed in the dark for the purpose of germination. The single

Table 4 Results of field tests 1951/52; Series I

Seed dressing	Application	Spore II		Spore IV		Spore VI		Spore VII		Spore VIII		Spore IX	
		Test field I % Infestation	Test field II % Infestation	Test field I % Infestation	Test field II % Infestation	Test field I % Infestation	Test field II % Infestation	Test field I % Infestation	Test field II % Infestation	Test field I % Infestation	Test field II % Infestation	Test field I % Infestation	Test field II % Infestation
untreated	—	33·4	32·8	34·6	32·3	37·9	27·4	27·7	—	37·9	30·0	30·1	34·0
A	75 g/100 kg	8·2	4·7	6·1	10·3	2·5	0·4	7·8	—	3·9	1·8	1·4	0·6
	150 g/100 kg	11·3	0·5	1·4	0·0	0·4	0·0	0·8	—	0·3	0·2	0·04	0·0
C	75 g/100 kg	7·6	0·5	3·8	0·2	4·5	0·1	2·7	—	1·7	0·1	0·6	0·6
	150 g/100 kg	0·4	0·0	0·5	0·0	0·3	0·0	0·3	—	0·2	0·0	0·0	0·0
D	0·05%—30' T	0·7	0·2	0·2	0·0	0·04	0·2	0·1	—	0·1	0·0	0·2	0·07
	0·1% —30' T	0·0	0·0	0·1	0·1	0·0	0·0	0·0	—	0·04	0·0	0·1	0·0
E	0·05%—30' T	1·3	0·6	0·6	0·5	1·2	0·4	1·6	—	0·2	0·3	0·7	0·07
	0·1% —30' T	0·0	0·1	0·0	0·1	0·0	0·1	0·1	—	0·0	0·0	0·2	0·0
F	0·05%—30' T	0·1	0·0	0·0	0·0	0·0	0·0	0·0	—	0·1	0·1	0·2	0·0
	0·1% —30' T	0·04	0·0	0·0	0·0	0·04	0·0	0·1	—	0·0	0·0	0·0	0·0
Water 18° C	30' T	31·4	21·5	28·6	19·3	22·7	14·5	27·6	—	26·8	17·7	35·9	23·5

Data for the test fields:	Test field I	Test field II	Wheat variety
Sowing date:	Oct. 18, 1951	Oct. 25, 1951	"Strubes Dickkopf"
Type of soil:	loamy sand	loamy sand	
Weather on date of sowing:	+ 5° C, fog	+ 8° C, sunny	
Humidity of soil:	9·9 %	—	
Previous crop:	Potatoes	Oats, rye	

Table 5 Results of field

Seed dressing	Application	Spore IV			
		"Carstens V" variety		"Heines IV" variety	
		Test field I % infection	Test field II % infection	Test field I % infection	Test field % infect
untreated	–	50·4	49·9	29·8	31·3
A	75 g/100 kg	5·4	2·8	8·1	4·9
	150 g/100 kg	1·0	0·4	1·7	0·5
C	75 g/100 kg	5·1	1·0	6·3	1·4
	150 g/100 kg	0·1	0·0	0·1	0·0
D	0·05 %—30' T	0·2	0·0	0·3	0·7
	0·1 % —30' T	0·0	0·0	0·0	0·0
E	0·05 %—30' T	0·2	0·2	2·4	2·0
	0·1 %—30' T	0·04	0·0	0·1	0·1
F	0·05 %—15' T	0·0	0·0	0·2	0·1
	0·1 % —15' T	0·0	0·0	0·05	0·0

spore varieties behave most differently at varying germination temperatures, a fact that Gassner had already established. In general, germination temperatures exceeding 18° C have an unfavourable effect. The tests were continued over a period of two years. Details are given in Table 7. The behaviour of the single spore types remained more or less the same in both years. The tests carried out with the different spores to establish the effect of the steep did not produce any results of an outstanding nature. There is, therefore, no necessity to tabulate them.

The described tests, therefore, produced no evidence of the formation of spore species capable of resisting mercury, and this was not to be expected in view of the circumstances since the mercury products are preparations which possess a general toxic action whereas the preparations with which the development of resistant species has been observed are free of heavy metals; the latter affect only very specific stages in the life-cycle and block individual reactions in the physiological phenomenon or deflect such phenomenon in another direction so that the organism is no longer capable of life or of reproduction. However, the question still remains unanswered why the dressing process often has an unsatisfactory effect against *Tilletia*. It has already been pointed out that external factors greatly influence the effect, in particular that of the dry dressing agent. However, a decisive role is also played by other influences. Recently Kirchner pointed out that the danger of infection

"Heines VII" variety		Spore VI					
		"Carstens V" variety		"Heines IV" variety		"Heines VII" variety	
est field I % infection	Test field II % infection	Test field I % infection	Test field II % infection	Test field I % infection	Test field II % infection	Test field I % infection	Test field II % infection
69·6	76·3	45·8	50·5	31·9	35·0	63·9	66·1
1·2	0·1	11·3	2·0	10·7	6·6	0·7	1·4
0·4	0·0	1·1	0·1	1·4	0·9	0·0	0·2
1·2	0·07	6·3	1·0	4·8	0·6	0·7	0·1
0·1	0·0	0·5	0·7	0·9	0·0	0·0	0·0
0·4	0·1	0·2	0·6	0·0	0·4	0·06	0·0
0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
0·6	0·0	0·4	0·06	0·5	0·5	0·3	0·2
0·1	0·1	0·04	0·0	0·0	0·0	0·06	0·0
0·05	0·0	0·2	0·2	0·0	0·06	0·06	0·0
0·0	0·0	0·2	0·0	0·1	0·0	0·0	0·0

occurring between dressing and sowing is extremely great, and it is to this possibility that failures may be attributed in far more instances than is often assumed to be the case. Furthermore, the endeavours made to be economical in the use of mercury, particularly with seed dressings A, D, and E, often lead to the limit of efficacy being reached with the result that added unfavourable conditions cause the occurrence of an even greater infestation. The improvement meanwhile made to several commercial preparations gives rise to the hope that far fewer failures will be experienced in future.

Summary

Tests carried out by means of selections from plots in which the seed had been dressed did not produce any proof that mercury-resistant species are formed.

In 1951 and 1952 tests were arranged with a large number of types from stinking smut spores. Even here there was no sign of mercury resistance.

The effect of the steep was considerably influenced by the degree of infection. The wheat variety exerted no influence upon the effect.

The results of the field tests were confirmed by comprehensive experiments carried out in the laboratory.

Table 6 Results of the field tests 1951/52; Series III

Seed dressing	Application	Spore IV		Spore VI		Spore X		Spore XI		Spore XII	
		Test field I % Infection	Test field II % Infection	Test field I % Infection	Test field II % Infection	Test field I % Infection	Test field II % Infection	Test field I % Infection	Test field II % Infection	Test field I % Infection	Test field II % Infection
untreated	—	47·8	47·7	44·1	51·2	63·3	63·1	38·7	43·0	42·3	52·3
A	75 g/100 kg	38·6	18·0	27·8	45·7	37·0	35·1	32·9	17·6	24·4	12·3
	150 g/100 kg	14·5	2·7	7·3	3·4	15·1	5·0	6·1	1·6	5·0	1·9
C	75 g/100 kg	11·0	1·9	9·3	2·7	18·3	2·4	8·5	3·2	9·3	1·2
	150 g/100 kg	0·4	0·0	0·2	0·0	6·1	0·5	1·7	0·7	2·6	0·0
D	0·05%—30' T	1·5	0·8	2·2	0·3	1·6	0·2	0·3	0·2	0·3	0·3
	0·1% —30' T	0·2	0·1	0·2	0·0	0·0	0·0	0·1	0·0	0·1	0·0
E	0·05%—30' T	2·3	0·5	1·5	1·9	5·1	1·9	2·4	1·6	0·9	0·5
	0·1% —30' T	0·1	0·0	0·4	0·3	0·1	0·2	0·0	0·1	0·1	0·2
F	0·05%—15' T	0·14	0·3	0·1	0·2	0·04	0·0	0·2	0·0	0·04	0·1
	0·1% —15' T	0·04	0·0	0·0	0·0	0·0	0·0	0·1	0·0	0·0	0·0
Water	30'T	36·8	36·8	36·4	31·5	49·4	42·9	34·0	27·4	40·1	30·7

Wheat varieties IV and VI: "Strubes Dickkopf"
Wheat varieties X, XI, and XII: unknown

Spore varieties IV and VI artificially infected 5 g to 1 kg
Spore variety X naturally infected 7·2 g to 1 kg
Spore variety XI naturally infected 3·4 g to 1 kg
Spore variety XII naturally infected 4·8 g to 1 kg

Table 7 **Results of temperature tests**

Spore variety	1951						1952			
	6 ± 1° C		11 ± 1° C		18 – 23° C		6 ± 1° C		11 ± 1° C	
	Start of germination after "X" days	more than 50% germinated after "X" days	Start of germination after "X" days	more than 50% germinated after "X" days	Start of germination after "X" days	more than 50% germinated after "X" days	Start of germination after "X" days	more than 50% germinated after "X" days	Start of germination after "X" days	more than 50% germinated after "X" days
I	9 3/4	17	4 1/2—5	10	4—5	6—7	8	15	4	8
II	9—10	18	5	10	5	8	8	15	4 1/2	8
III	–	—	—	—	—	—	10	15	4 1/2	8 1/2
IV	7—8	16—17	3 1/2—4	8—9	4—5	5 1/2—6	8	14 1/2	4 1/2	8 1/2
V	8 1/2	16	4	8	5	several delayed otherwise 7	8 1/2	15	4	8
VI	9	17	4 1/2	9	hardly germinated	—	9	15 1/2	6	9 1/2
VII	10	18	5	9 1/2	5	6—7	8	14	4	8
VIII	9 1/2	15	5	10	irregular	—	8 1/2—9	15	6	10
IX	9—10	15—16	4 1/2	10	irregular	—	8—9	14—15	5	10
X	—	—	—	—	—	—	8 1/2	16	5	10—11
XI	—	—	—	—	—	—	8 1/2	17	5 1/2	9
XII	—	—	—	—	—	—	10	19	5 1/2	10—11
XIII	—	—	—	—	—	—	8	18	5	15

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Outdoor Tests with "Systox" to Control the Fruit-Tree Spider Mite, *Paratetranychus pilosus* Can. et Fanz.

By Dr. G. Unterstenhöfer

In recent years spider mites *(Tetranychidae)* have become important pests, from the economic point of view, in connection with cultivated plants upon which they previously had little or no effect. It is particularly in fruit growing that the *Tetranychidae* are assuming the proportions of a large-scale pest. In this instance the species involved are *Paratetranychus pilosus, Bryobia praetiosa* and more recently *Tetranychus urticae* as well as a new species of *Septanychus* (2, 4). The cause of this excessive propagation is probably attributable to a variety of factors, the extent and combination of which it is not yet possible to determine. One is the increased use of the winter spray and of some synthetic insecticides which have only a slight acaricidal effect or none at all on the one hand but which, as a result of their effect upon insects on the other hand, destroy important natural enemies of the spider mites thus removing a natural factor limiting the spider mites' mass development (3). Other factors include the Bordeaux and lime sulphur washes, which are supposed to exercise stimulating influence upon the mites via the surface of the leaf (7). In view of the seriousness of the problem, therefore, it is of the utmost importance that increased interest should be devoted to the study of the biology and epidemiology as well as to the control of the spider mite. In compliance with this pre-requisite, valuable contributions have been made in the course of time towards solving the individual questions.

The tests outlined on the following pages are only concerned with the control of *Paratetranychus pilosus,* the pest which is still chiefly responsible for economic losses in commercial fruit growing in Germany, whereas *Bryobia praetiosa* is more predominant on standards.

Under the conditions mentioned, only the use of a chemical control agent can guarantee successful protection against damage by spider mites in fruit growing. The direct control of the mites with acaricidal agents is, however, difficult when compared with other pests. This is due, on the one hand, to the habits, mass development and behaviour of the fruit-tree spider mite and, on the other hand, to the way in which the control agent operates. It may be summarized (a good knowledge of the biology of *P. pilosus* must be assumed) under the following headings:

1. The spider mite lives in a finely spun and difficultly wettable web usually found on the underside of the leaf and, in consequence of this, it is difficult to reach when spraying.

2. Under different conditions, 4—5 generations develop during a year. When the conditions of development are favourable, a few individual mites can cause widespread infestation.

3. The emergence of the larvae from the winter eggs begins and ends about blossom time, mostly at the time the tree is in bloom, when the use of control agents is not permitted in order to protect bees, and it is just at this time, namely during blossom, that the summer eggs too are generally laid.

However, at this time of the year the growth of foliage on the tree is very rapid. In May it is possible for the foliage to spread considerably within a period of a few days (3, 6). This means that the lasting effect of the agents at

such a time, even if there is no rain or strong wind (as regards the preservation of the spray coating, the rubbing and brushing action caused by the leaves coming into contact with each other when blown by the wind is considered more important than rain), will be limited in scope as a result of the new growth which is not coated by the spray (3).

4. The agents available until now have been effective against either the eggs or the post-embryonal stages, but not against both stages of development (stage specificity of the poisons). A distinction can be drawn between different stages of susceptibility, between the winter eggs, the summer eggs and the post-embryonal stages, in the case of which a further subdivision is usually made into mobile and resting stages.

According to the effect produced by the agent, control with chemicals can be started:

a) upon the winter eggs during the dormant period;

b) against the first generation in the spring, when the emergence of the larvae from the winter eggs is completed and summer eggs have not been laid. A second spraying should be given about 10 days later:

c) against the population consisting of eggs and the post-embryonal stages during the post-blossom period.

Even if the effect achieved by the agent is good, the control of spider mites by destroying the winter eggs with winter sprays does not result in the degree of efficiency which must be called for on the basis of the propagation potential inherent to the species and hence the number of generations, in order to save the use of further control measures during the period of growth. For those carrying out the spraying work it is virtually impossible, technically speaking, to bring the partly concealed eggs into contact with the control agent to the extent desired. This is all the more applicable where the winter eggs are laid in large quantities on the side of the tree protected from the wind, which, since spraying should not, if possible, be carried out against the wind, always receives unsatisfactory coatings during winter spraying. The value derived from winter spraying lies mainly in the fact that, where the number of eggs laid is high, the heavy damage caused by the first generation during blossom time can be reduced. Were it not for this, the mites could concentrate in large numbers upon the young foliage present at that time. Experience has shown that, under favourable conditions of development, summer control is necessary in addition to effective winter spraying.

For the exclusive control of spider mites during the period of growth, two sprayings are recommended at the times mentioned at b), bearing in mind the fact that the control agents have an effect upon the post-embryonal stages but do not act ovicidally. These are the weak points for the insect where the best results can be achieved with the minimum amount of expenditure of both time and money. This method has repeatedly produced good results. In some years, however, it is not possible to put this scheme into operation, due to the fact that the control period occurs during blossom time. Moreover, early damage to the young foliage cannot thus be avoided and this is of the greatest importance. This method of control, which has always been recommended and considered most likely to produce promising results, is not, therefore, at all satisfactory.

Finally, the third method of carrying out control, where there is a population present comprising all stages, calls for a positive lasting effect in view of the strong specificity of the agents. This is only obtained under exceptional conditions resulting from dependence upon rain, wind and growth of foliage.

Successful results are only obtained with part of the population, namely with those pests in the susceptible stages of development present at the time of control and those which enter the susceptible stage shortly afterwards. Apart from the fact that repeated measures are necessary, which also have the effect of increasing the cost of control, the damage caused up to the time of spraying, which cannot be remedied, has to be tolerated and in this way the economic effectiveness of the counter-measures suffers in addition.

The problem to be surmounted is thus one of organizing the control of spider mites upon a cheaper and more positive basis. To do this, it is necessary to prevent a mass development of the mites at low costs. In this respect the use of a systemic control agent can be considered most likely to produce successful results. By this method a positive lasting effect is achieved through the chemical present in the plant by exclusion of external mechanical influences. This effect also extends its influence to new growth. Likewise, in cases where stage specificity is present in the agent, the unsusceptible stages enter a susceptible stage at some time during the total period of effect of the agent and are therefore killed off, so that virtually a complete population is destroyed. The introduction of the systemic insecticide "Systox" fulfilled this requirement. Z a t t l e r (5) has already made a detailed report on his experiences with "Systox" in the control of *Tetranychus althaeae* on hops. However, these experiences cannot simply be transferred in their application to *P. pilosus,* owing to its different way of life, the different hosts and the differences in the susceptibility of the species. Special investigation is required in this respect.

After experiments in the laboratory and informative tests undertaken outdoors had established the effectiveness of "Systox" against the fruit-tree spider mite, field tests for the control of this pest were carried out in 1951 and 1952. In these tests control was concentrated both upon the periods before and after blossom time, with particular consideration for the destructiveness of the first generation upon the young leaves. Pre-blossom spraying is based upon the idea that the foliage in existence at that time should be provided with a supply of "Systox" by means of which the larvae emerging from the winter eggs are exterminated on the leaves. In order to achieve this, the lasting effect would have to be prolonged sufficiently to include virtually the whole of the first generation. The population present on the tree would thus be completely destroyed or so badly decimated that disaster on a large scale would not occur during the period of growth. It is true that wind movements would cause fresh colonization, the importance and intensity of which cannot be assessed.

The object of the post-blossom spraying is to destroy the population present at that time. With this spraying the possibility must also be considered that the emergence of the larvae from the winter eggs only begins late in the season or that blossom time is prolonged, so that the effect is not of sufficient duration to embrace those larvae emerging last.

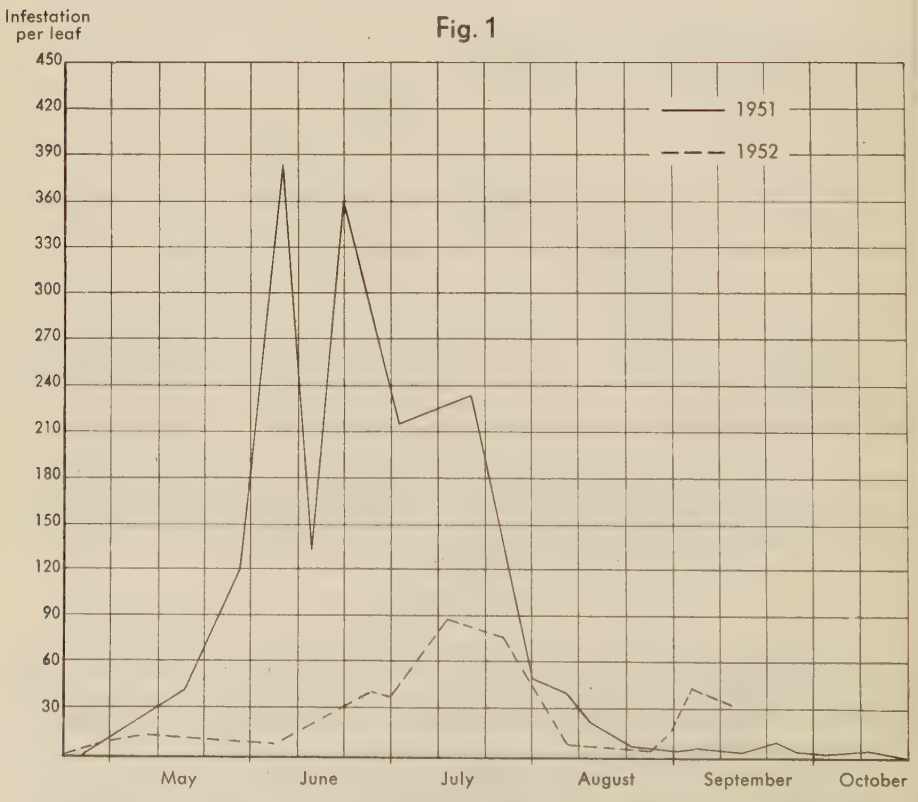
Test arrangements

Bushes belonging to different varieties were selected for the pre-blossom and post-blossom spray tests carried out in 1951. During the following year these tests were extended to 100 bushes in order to gain at the same time more experience regarding secondary effects. The stock of bushes made available for the tests had not been treated in 1951. Spraying was carried out by means of a motor sprayer, and 1—2 litres of a 0·05 % "Systox" solution were applied to each bush. During the whole period of growth experimental bushes were treated exclusively with fungicides which had no acaricidal effect, insecticides being left

out of the tests completely. The evaluation of the experiment was carried out in such a manner that the degree of infestation of mites and eggs was ascertained on 30 leaves. These tests involved 3 × 10 leaves. For the purpose of the tests single leaves were taken from various leaf clusters of four branches on the North, South, East and West sides of the bush, respectively, starting from the stem outwards. The mites were then counted under the binocular microscope. The evaluation was made on the Early Victoria (Frühe Viktoria), a variety which had suffered particularly as a result of the mite infestation.

Observations on the progress of the population during the experimental period

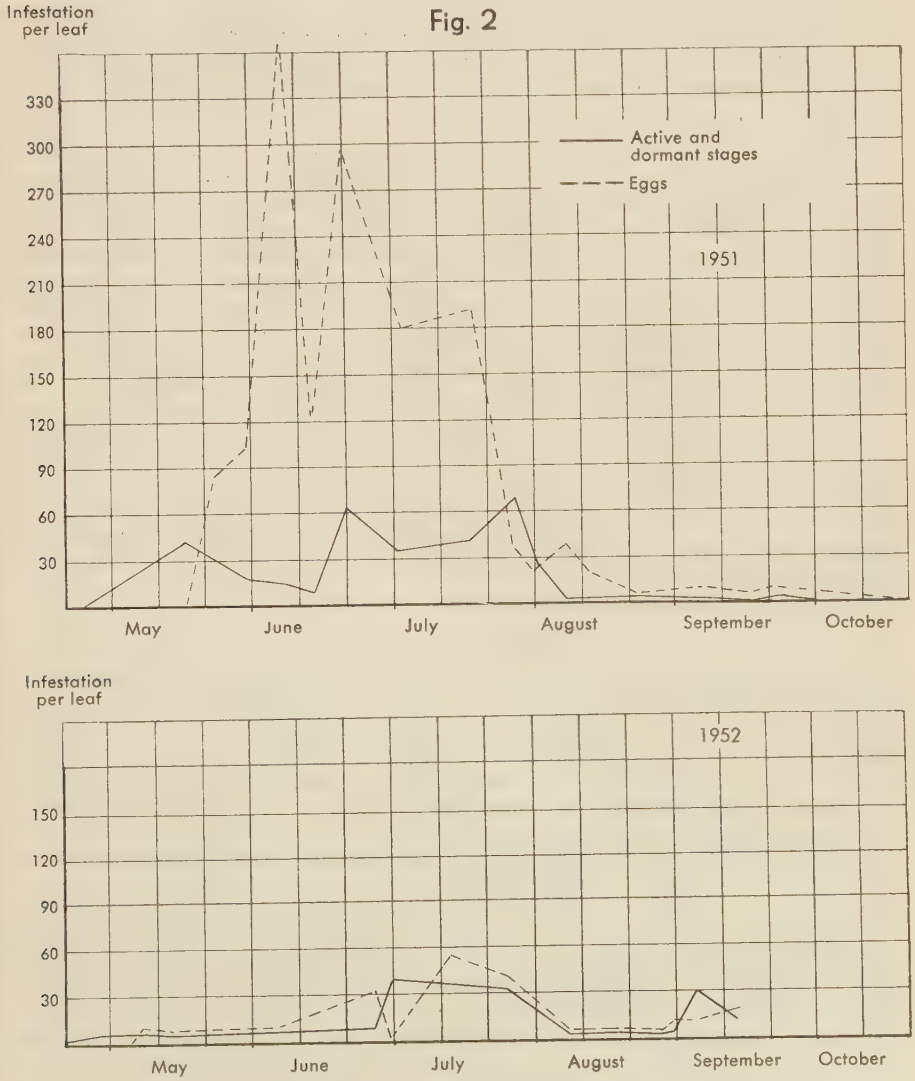
Graph 1 depicts the progress of the *P. pilosus* population on Ellison's Orange apples, a variety which had been subjected to no control measures whatsoever for a period of two years and on which the spider mites had been able to develop without hindrance. It is revealed that the progress of the population varies considerably in the two experimental years. Corresponding with an extremely heavy deposit of winter eggs during the winter of 1950/51, a very high degree of infestation developed in the early summer of 1951 which reached its climax



Population progress of P. pilosus on Ellison's Orange 1951 and 1952 (Eggs and mites per leaf)

at the beginning of June until the end of July. Under the influence of the adverse nourishment conditions resulting from the damage which the mites themselves had inflicted and because of the activities of natural enemies, the population died out almost completely during the further period of growth. Consequently, fewer winter eggs were again laid, so that the weak initial deposit in 1952 therefore caused a deceleration in the growth of the population. The 1952 degree of infestation was far below that of 1951, and this time the climax was reached in

Fig. 2



Population progress of P. pilosus on Ellision's Orange (Infestation per leaf)

the middle of July. Thus the experience is confirmed that years with heavy infestation of mites usually end with a small deposit of winter eggs and consequently the start of the mite population development in the following year is considerably hindered.

Graph 2 illustrates the chronological progress of the infestation in two sections, on the one hand the mobile and resting stages, and on the other hand the summer eggs.

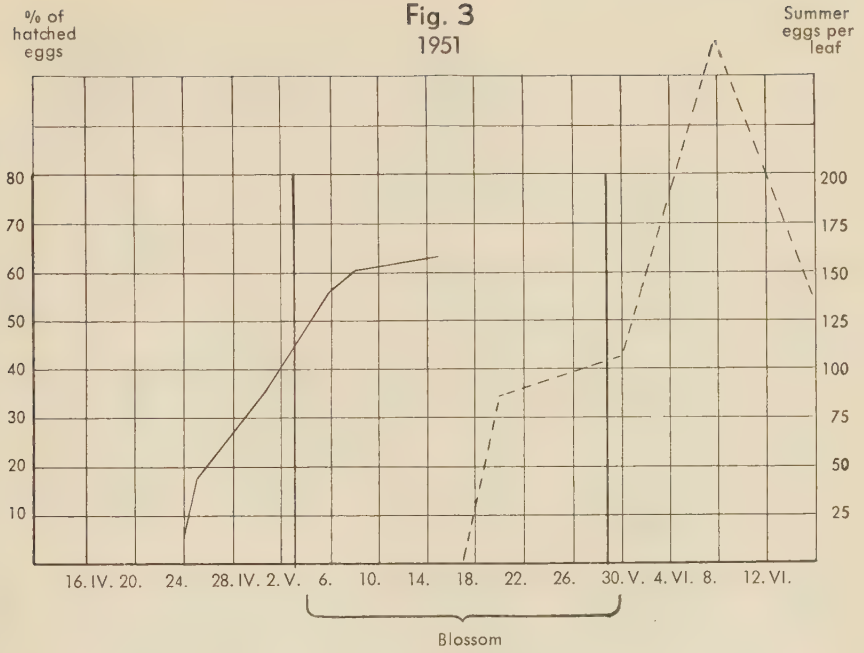
It has been customary in the past to recommend that sprays be carried out in early spring at a time when the winter eggs have hatched but prior to the laying of summer eggs, and in view of this it is interesting to determine to what degree this particular period could be made use of under the test conditions mentioned.

Graph 3 illustrates the chronological progress of the emergence of the larvae from the winter eggs and the beginning of summer egg laying in relation to the fruit tree blossom time. In 1951 hatching began during the last 10 days of April and ended about the middle of May. The majority of the winter eggs hatched out in the pre-blossom period and only approximately 30 % in the blossom period. The first summer eggs were laid about the middle of May when the trees were in full blossom. It was not possible to adhere to the recommended spraying date, out of consideration for the bees. 1952 produced in principle the same picture with the exception that the dates were advanced by about two weeks so far as the hatching, laying of eggs and blossom time were concerned. It is true that the majority of eggs hatched out during blossom time and the start of summer egg laying occurred in the latter part of blossom time but, nevertheless, it was again not possible to adhere to the time recommended, although the gap was this time less than in 1951. Even so 60 summer eggs per leaf had already been laid (about 140 in 1951). It is worth mentioning that between 60 % and 70 % of the winter eggs hatched out in both years. This finding is somewhat contrary to the results established by other observers, according to whom the hatching percentage is higher.

Results of the tests

In 1951 the pre-blossom spraying was carried out on 26th April. This resulted in a degree of effectiveness (eggs and mites compared with infestation on the plant used for checking) amounting to 95 % after 12 days and 93 % after 21 days. In the same year post-blossom spraying was carried out on 30th May. After 24 hours this provided a degree of effectiveness of 96 % (mites) and 92 % (total population) after 3 weeks. A fuller account of the tests during 1952 now follows. The pink bud spraying was carried out this time on April 18th, that is, eight days earlier than in 1951 and at a very favourable time in relation to the beginning of blossom period. At that time the amount of foliage present was small. The petal fall spraying took place on May 13th. The evaluation dates were on April 25th, May 6th, May 16th, June 5th and September 2nd. Table No. 1 lists the result of the count. The average degree of infestation upon 10 leaves is listed together with the corresponding mean error and the degree of effectiveness calculated in accordance with A b b o t t ' s (8) formula. In view of the high degree of efficiency, a statistical survey of the results appears to be superfluous, in spite of the presence, to some extent, of higher mean errors, since the differences in the degree of infestation shown may be regarded as reliable according to general experience.

Fig. 3


1951
% of hatched eggs
Summer eggs per leaf
80
70
60
50
40
30
20
10
200
175
150
125
100
75
50
25
16. IV. 20. 24. 28. IV. 2. V. 6. 10. 14. 18. 22. 26. 30. V. 4. VI. 8. 12. VI.
Blossom

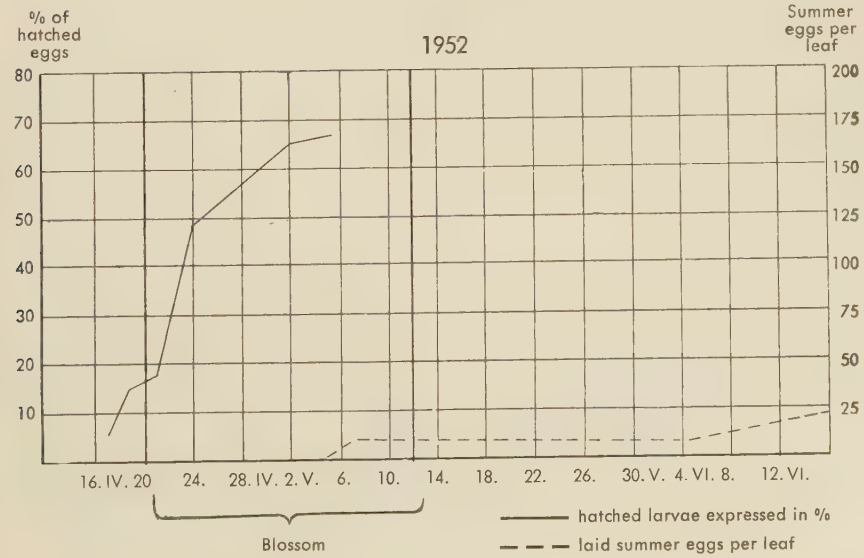

1952
% of hatched eggs
Summer eggs per leaf
80
70
60
50
40
30
20
10
200
175
150
125
100
75
50
25
16. IV. 20 24. 28. IV. 2. V. 6. 10. 14. 18. 22. 26. 30. V. 4. VI. 8. 12. VI.
Blossom
hatched larvae expressed in %
laid summer eggs per leaf

Table 1

Date of evaluation	Spraying date	Mobile and resting stage. Mean incidence of infestation on 10 leaves	Eggs Mean incidence of infestation on 10 leaves	Degree of effectiveness in percentage. (Total population = eggs and post-embryonal stages)
April 25th	Check	163·0 ± 20·2	—	—
	Pre-blossom (18. 4. 52)	8·7 ± 0·8	—	91·5 ± 3·6
May 6th	Check	175·0 ± 80·9	—	—
	Pre-blossom	1·0 ± 1·0	—	99·1 ± 0·9
May 16th	Check	36·3 ± 11·3	1779·0 ± 172·2	—
	Pre-blossom	4·3 ± 1·48	15·7 ± 3·32	99·4 ± 0·2
	Post-blossom	6·0 ± 3·6	828·0 ± 283	57·2 ± 22·6
June 5th	Check	488·7 ± 144·9	1652·0 ± 45·5	—
	Pre-blossom	2·0 ± 1·0	28·3 ± 11·1	98·5 ± 0·31
	Post-blossom (13. 5. 52)	12·3 ± 3·46	64·7 ± 30·2	96·4 ± 0·25
September 2nd	Check	64·3 ± 19·9	532·0 ± 73·1	—
	Pre-blossom	184·0 ± 43·4	846·3 ± 166·7	—
	Post-blossom	65·0 ± 9·29	283·7 ± 45·4	—

The evaluation made on April 25th, i. e. 7 days after the pre-blossom spraying, revealed a degree of effectiveness of nearly 92 %. The mites found upon the leaves were, almost without exception, recently hatched larvae. In the first stages of blossom time, when the majority of the larvae had emerged from the winter eggs, less than 10 % of the number of mites present on untreated trees were to be found on trees which had received treatment. Upon the occasion of the second evaluation on May 6th the degree of effectiveness was still higher, namely 99 %. The last winter eggs had hatched. The population present on the tree had been almost completely destroyed by the pre-blossom spraying and the resultant long immunisation of the chlorophyll. The animals still to be found were, almost without exception, recently hatched larvae, which had either emerged late from the winter eggs or had been carried there by the action of the wind. The result of the third evaluation on May 16th was virtually identical to the previous one. The position had thus changed very little during the course of a further ten days. It is true that there were some isolated mites and also some summer eggs but these were most probably blown there by the wind in the manner mentioned in the preceding evaluation findings. The first important result obtained from these evaluations is that it was possible to achieve the aim of bringing the tree through the critical blossom period without damage and to obstruct the commencement of a mass attack by the destruction of the first generation. Also in the case of the third evaluation on June 5th, almost seven weeks after the spraying, the degree of effectiveness still amounted to almost 99 %. However, not only the relative but also the absolute incidence of infestation was insignificantly small, the figure being 2 mites and 28·3 eggs to 10 leaves. Such few mites were virtually incapable of causing further

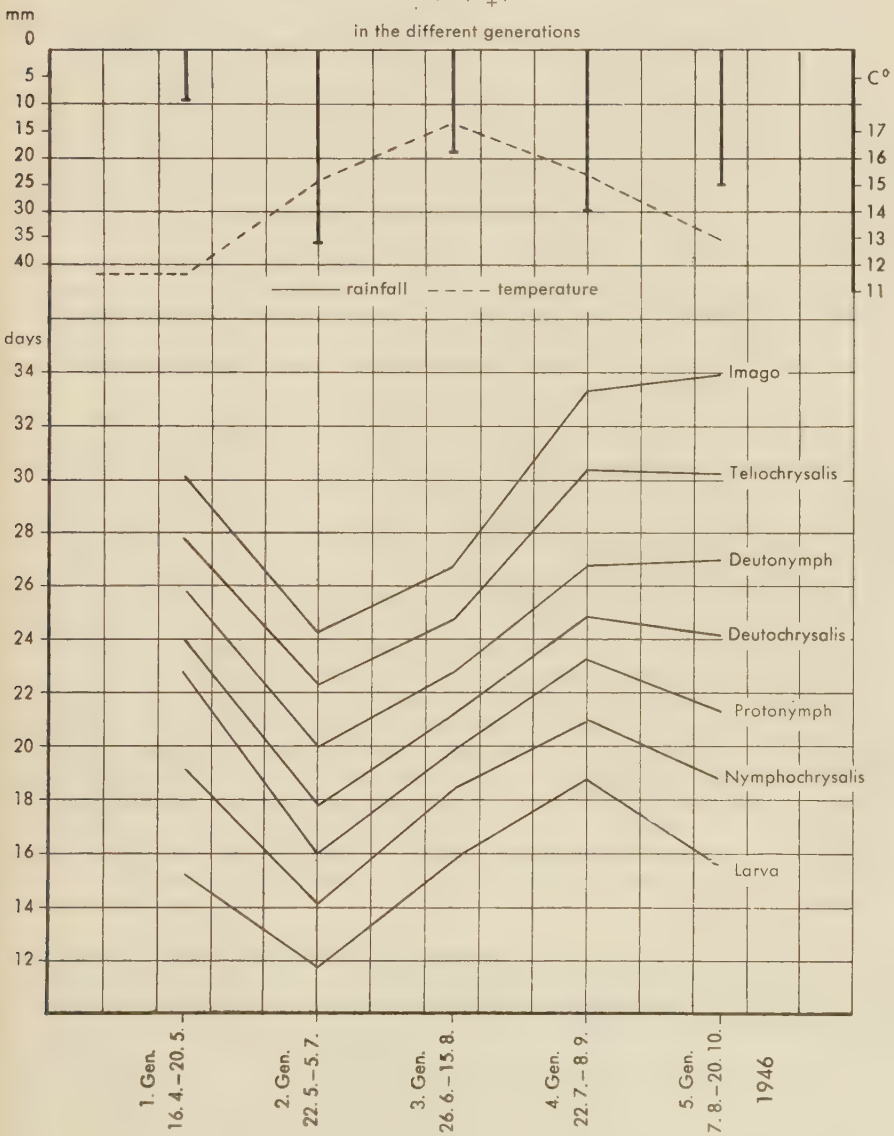
Graph I

Average period of the embryonal and juvenile development of

Paratetranychus pilosus

(only ♀)

in the different generations



damage and the prospects offered for further development and a mass attack were unfavourable. At this stage, there was a marked contrast between the treated trees, with their dark green leaves, and the untreated trees. In the case of the latter, besides the typical originally formed leaves, bronze-coloured and halted in their development, there was evidence of characteristic damage by spider mites on the remaining foliage. A final evaluation was made on September 2nd. This was intended to show whether, in connection with the success mentioned above, it was possible for a greater incidence of infestation to build up on the treated trees during the course of vegetation. This was definitely the case, as shown by the numerical findings. It may be explained by the fact that, as a result of mites and eggs being blown by the action of the wind, a larger number of individuals gathered on the foliage during the subsequent weeks and, under the favourable food conditions offered by the undamaged leaves, were able to bring about a corresponding increase in their numbers. However, this fresh increase in numbers is not of economic importance, as the appearance of the trees demonstrates, and would not, in our opinion, justify spraying.

When the post-blossom spraying was carried out on May 13th, a considerable number of mites was found on the trees, as the results of the check show. In the preceding weeks during blossom time, these had already caused damage to the early foliage which was clearly visible and not to be underestimated in its extent. For this reason it was of the utmost interest to determine what effect a single spraying would have upon a population comprising all stages of susceptibility. The first evaluation three days after the spraying revealed the expected picture; severe decimation of the post-embryonal stages, of which those detected were exclusively young larvae, and a very large number of summer eggs still present. The subsequent evaluation on June 5th showed that a degree of effectiveness amounting to 96 % had been attained. During the course of the poison's period of effect, the resistant or immune stages became susceptible mobile stages which were destroyed in succession upon the treated foliage. The task required of the insecticide, that of destroying a population of mites, was fulfilled. However, when making a complete appraisal of the situation the effect of the post-blossom spraying was found to be inferior to that of the pre-blossom spraying under the existing test conditions. This is due to the fact that it was not possible to remedy the serious damage caused to the early foliage during blossom time. The result of the latest evaluation on September 2nd also brought no changes in the situation. According to this evaluation, the degree of infestation upon the trees treated in the post-blossom period is considerably lower than that recorded upon untreated trees and those treated in the post-blossom period. Furthermore, during vegetation, convincing evidence of the effect of the post-blossom spraying was provided by the healthy appearance of the trees.

In order to determine the influence of these measures upon the yield of fruit trees, the total yield of windfalls and picked fruit was calculated for each of three trees of the Early Victoria (Frühe Viktoria) variety, upon which counts had been conducted. The results are shown in Table No. 2. Even if three trees are insufficient to calculate yield data, owing to the large variations in individual cases, the results of the observations do reveal the general effects produced by "Systox" in the control of spider mites. The higher mean errors are mainly attributable to the fact that the mean value shown was calculated from the results obtained from each of two trees on the EM 2 type of root-stock and one tree on type 13 of the root-stock. In the case of root-stock 13, the yield in general was considerably greater than that of root-stock 2.

Table 2

Spraying date	Mean yield per tree in kgs			Windfalls in % of the total crop	Rel. Increase in yield (Check = 100)
	Windfalls	Picked fruit	Total		
Check	16·0 ± 11·9	28·0 ± 10·1	44·1 ± 3·1	36·3 %	100
Pre-blossom	13·0 ± 6·3	53·3 ± 18·2	66·34 ± 25·0	19·7 %	151
Post-blossom	9·2 ± 3·1	46·8 ± 27·3	52·69 ± 35·0	17·3 %	120

The table shows that the total yield from the treated trees is considerably above that of the untreated trees. The pre-blossom spraying was the most successful and produced a result which is in agreement with the counts and the visual impressions obtained during the period of the tests. It is also worth noting that it was possible, by means of spider mite control measures, to reduce the proportion of windfalls in the total yield.

It should again be emphasized that we only ascribe informative significance to the results relating to yield reproduced here. No record was made of any secondary effects during the period of the tests.

Summary

During outdoor tests lasting two years, the question was examined as to whether a single spraying of "Systox" 0·05 % solution could reduce the degree of infestation to an economically insignificant level in the case of the fruit tree spide mite *Paratetranychus pilosus* and also at which period it was most practical to carry out this spraying. It was found that the pink bud spraying is the most practical under the conditions mentioned, since the treated trees are protected by it from the particularly serious damage caused during blossom time and the degree of infestation during vegetation is also reduced to proportions which are of economic insignificance. The post-blossom spraying produces virtually the same picture as far as the degree of effectiveness is concerned but, in the case of sprayings carried out at this stage, the damage caused during blossom time has to be tolerated. The results relating to yield, which are purely of an informative nature, verify the findings in connection with incidence and at the same time point to the economic importance of spider mites in general and the damage during blossom time in particular.

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Successful Measures taken against Yellow Disease in Beets by controlling Virus-Transmitting Aphids with "Systox"

by Dr. Dame and Dr. H. Goossen
of the Plant Protection Office, Münster (Chamber of Agriculture, Westfalen-Lippe).

Many years of experimental work carried out by Steudel and Heiling (1951, 1952) have shown that the yellow disease in beets (Fig. 1) can be successfully controlled by suppressing infestations of the virus-transmitting aphids species *Myzodes persicae* and *Doralis fabae* with the systemically effective preparation "Systox". The extent to which the disease occurred in Westfalen-Lippe and the positive test result mentioned above led to the Plant Protection Office Münster, in close co-operation with the agricultural colleges and the sugar factories in Soest and Lage, carrying out experiments in 1953 in Westfalen-Lippe to test for the first time the new method of controlling yellow disease in beta beets and to find out whether it could be employed in field work as a whole. This report deals with the experiences gained during the course of the experiments.

Fig. 1. Yellow disease in beets

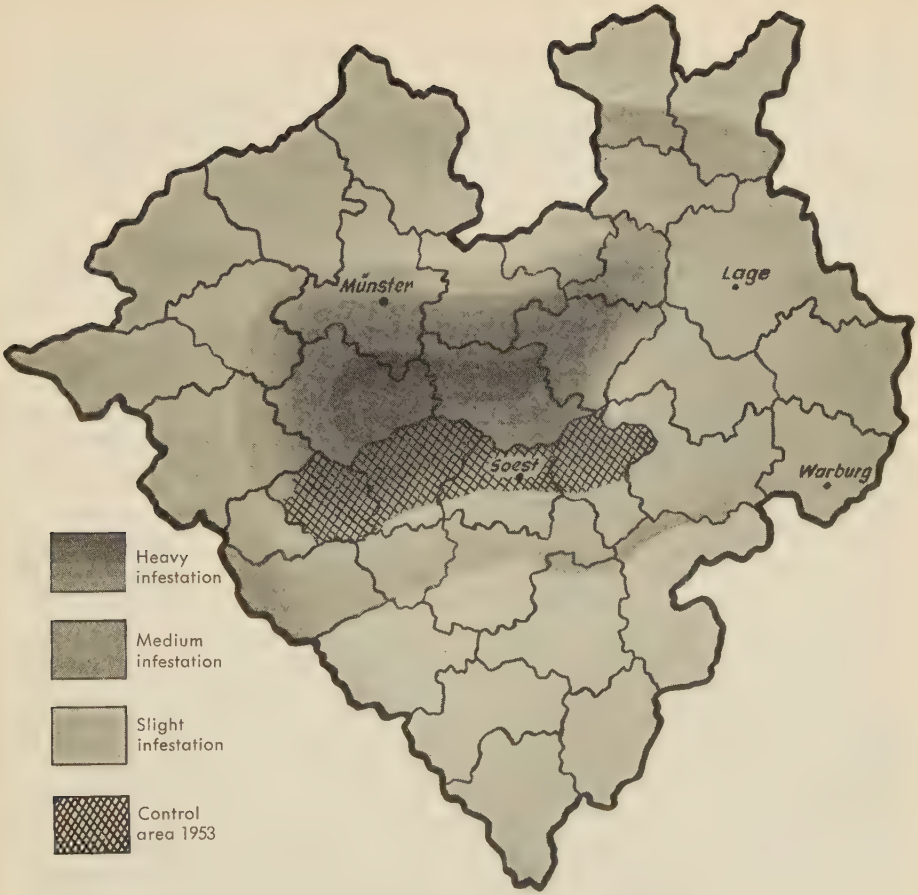


Fig. 2. Occurrence of yellow disease in Westfalen-Lippe 1952

I. Occurrence and significance of yellow disease in Westfalen-Lippe

All the beet fields in Westfalen-Lippe are affected by yellow disease although not to the same extent in every district. The actual situation (according to Heiling and Steudel) is illustrated in Fig. 2.

The various degrees of infestation may be defined as follows:

Heavy infestation:

Occurrence:

100 % early infestation of all fields (July-August). *Myzodes persicae* is chiefly responsible for the infection.

Average yield losses:

20—30 % beets,
12—20 % leaves,
1 % polarisation decrease,
to 50 % decrease in the nutrient content of the leaf.

Medium infestation

Occurrence:

50—60 % infestation by the beginning of August, 100 % infestation by the middle of September. Serious cases of damage are to be found chiefly in those fields cultivated late and showing sparse growth.

Average yield losses:

10—20 % beets,
10 % leaves,
0·5 % polarisation decrease,
to 30 % decrease in the nutrient content of the leaf.

Slight infestation

Occurrence:

Late infection transmitted chiefly by *Doralis fabae*. If at all, the *Myzodes persicae* species does not start its transmitting activities until much later. Up to 70 % infection under favourable transmitting conditions.

Average yield losses:

Heavy losses mostly only local. Leaf depreciation may, however, be much greater in the case of a late infection than in areas where there is an early and heavy infestation.

An epidemic occurrence of yellow disease was observed for the first time in Westfalen in 1938 close to the Dutch frontier. Beet Yellow started to make a general appearance in 1945 in those beet growing areas (Fig. 2) which are today regarded as being heavily infested. In 1946 the infestation was weak and was due to the small scale occurrence of *Myzodes persicae*. From 1947 onwards, however, the yellow disease began to take a greater toll of the harvest. The harmful influence of the disease is made particularly manifest by the decrease in the sugar content (yearly averages) of the sugar beets supplied to the sugar factories between 1947 and 1952 (Table 1). The effect of such reductions in the content of sugar is that the processing of the sugar beets at the sugar factories is made all the more difficult. Attempts are being made in Westfalen-Lippe to counteract this decrease in sugar content by growing only N-beets. Naturally growers have to put up with the fact that the hectare yields are much lower than in the cultivation of E-beets.

Table 1: Decrease in sugar content from 1947—52.

Year	Sugar factory		
	Soest	Lage	Warburg
	Sugar content in %	Sugar content in %	Sugar content in %
1947	17·05	17·17	17·45
1948	16·8	16·84	17·41
1949	15·0	15·81	17·35
1950	15·9	16·67	16·52
1951	15·2	16·97	16·59
1952	14·67	16·04	15·77

II. Formation of control groups

The carrying out of essential cultivation work and suitable hygienic measures, liberal and early fertilization, sowing at the right time, correct spacing and the control of all diseases occurring in beets during the juvenile stages are absolutely essential as preventative measures although they are not in themselves sufficient to check the infestation to a satisfactory degree in those areas where there is a heavy occurrence of yellow disease. It was therefore deemed necessary to acquaint beet growers with the chemical control methods. Suitable conditions for doing this were offered by the area between Dortmund and Paderborn where sugar beet is grown on a large scale and which every year suffers most heavily from yellow disease (Fig. 2). Participation in the control action was a voluntary matter for every beet grower. In order that the necessary treatments could be carried out at the right time, every effort was made to form special control groups.

Details of the control work were discussed with beet growers at 30 district and village meetings. A total of 20 control groups was set up, and each district was provided with a suitable sprayer purchased out of Federal or Regional Funds. The areas were divided up in such a manner so that one sprayer would not have to be used for more than 100 hectares of beets. The power driven sprayers, either mounted on tractors or designed as tractor-drawn trailers, manufactured by Messrs. Fricke, Messrs. Holder, Messrs. Pflanzenschutzgeräte G. m. b. H. and Messrs. Platz proved to be most suitable for this type of work particularly as a result of their long spraying range (10 m, 10·5 m and 20 m). The tractors used to mount or draw the sprayers were provided by a beet grower in each district against payment. The tractor drivers and spray operators were nominated by the control group, trained by the Plant Protection Office and constantly advised during the period of control. A particular feature of the training was the detailed information given about the precautionary measures that have to be taken when working with "Systox". Tested respirators manufactured by Messrs. Bartels & Rieger, Cologne, Bayenthal, and Draeger, Lübeck, were purchased out of Federal Funds and placed at the disposal of the spray operators and tractor drivers, together with spare filters, for the period of the control. The spray operators and tractor drivers obtained their own barrier cream ("Fissan", Deutsche Milchwerke, Stauffenberg, Bayern; "Nirosol", Heinrich Marsch, Illertissen, Bayern; "Aretil", Chemische Fabrik, Stockhausen-Krefeld; "Chemosan", Imhausen, Witten-Ruhr), rubber gloves, protective suits and rubber boots. As a rule the purchase costs are set off against the yield of the area treated. Since the spray operators and tractor drivers all lived in the area were they were working they were available for spraying at all times which proved to be most favourable since spraying always had to be carried out at short notice occasioned by the unsettled weather.

The treatment costs borne by the beet growers for carrying out spraying (wages for the spray operator and tractor driver etc.) and for purchasing the preparation "Systox" amounted for a single spray to DM 36·00 per hectare. In 1953 "Systox" was not on sale to the general public, and the sugar factories at Soest and Lage undertook to buy the preparation on behalf of the trained control groups. The sugar factory at Soest financed all purchases of preparation used by the beet growers in their district, this being deducted accordingly when the growers were paid for their consignments of beet. The sugar factory at Lage bore the costs themselves incurred for preparation used in the experiments on 31·4 hectare of beet fields in the Detmold area.

III. Aphid warning service

An aphid warning service financed by the Regional Government of North Rhine Westphalia was set up to determine the correct dates for spraying. The observations made in the control district by three specially appointed experts covered:

1. aphid development on peaches *(Prunus persica)*, Viburnum, spindle tree *(Evonymus europaea)* and other hibernation sites;
2. the migration of aphids to the beet fields;
3. checks of aphid infestation on the beets.

As a result of the unfavourable weather prevailing in spring, there was only a small colonisation of aphids on peaches, Viburnum and spindle trees. The migration of the aphids from their winter hosts to the beet fields was continually interrupted by rain, and consequently the numbers of catches made with the M ö r i c k e aphid trap varied considerably (Fig. 3).

The aphid counts made in the beet stock were used as the basis for carrying out the first spray. Infestation figures were obtained by means of both the 100 beet plant method and the 100 beet leaf method thus rendering it possible to fix an exact date for carrying out the control. It was found, however, that it was far simpler and quicker to take counts in accordance with the 100 leaf method, and that these gave a far better picture of the actual degree of infestation when the beets were in an advanced stage of development. As a result *Doralis fabae* only occurred in clusters. In view of this, the more uniform infestation of *Myzodes persicae* was taken as a guide for carrying out the first spray. The occurrence

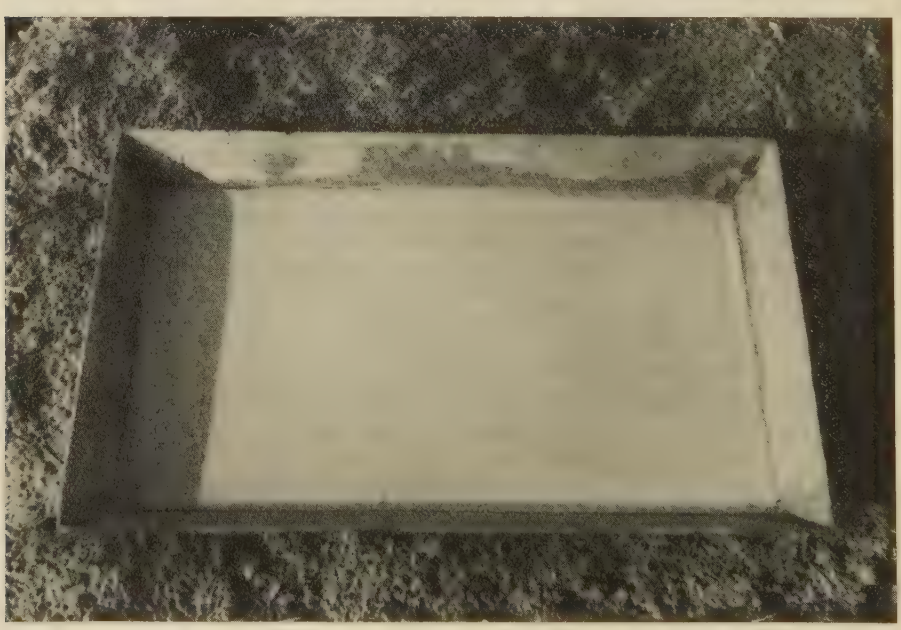


Fig. 3. Aphid trap for checking the flight of the insects

Fig. 4. Spigot-pipe type tractor-mounted sprayer ("Alldog") with 10 m spraying range

of 30—50 *Myzodes persicae* on each 100 plants was to be the signal for the first spray which in the greater part of the control area was fixed to be carried out on June 22, 1953. It was only in the western parts of the control area that spraying had to be started 8—14 days earlier. In comparison with the previous year the aphids occurred about one month later, and numerically the infestation was much weaker than in 1952. Consequently the yellow disease did not occur to the same extent as in the previous year. The main reason for this may be attributed to the prevailing weather conditions which in 1953 were favourable for beet development but unfavourable for the development of the aphids.

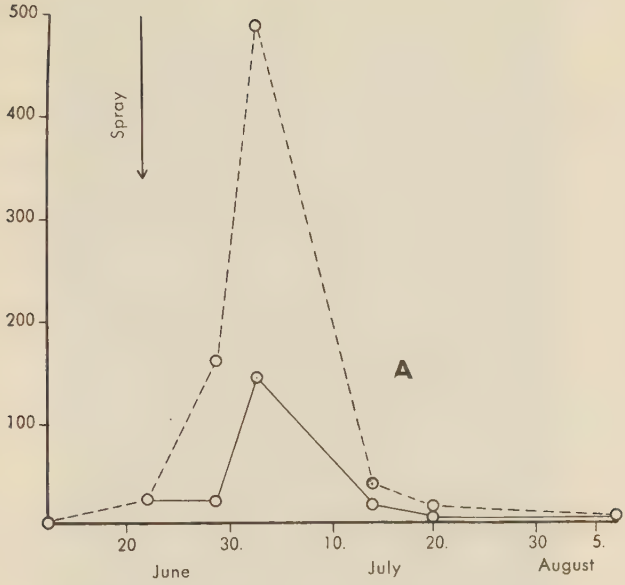
IV. Carrying out the sprays

Due to the late occurrence of the aphids even the first spray had to be carried out in the densely growing beet rows. Afraid that damage may be caused to the beet stocks, a number of growers refused to spray the beet fields at such a late time in the season with the result that only approx. 1000 hectares were sprayed out of a total of 1600 hectares originally put down for spraying. After the fields had been treated it was found that no great damage had been caused to the beet stocks irrespective of whether tractor-drawn power sprayers or tractor-mounted power sprayers ["Alldog" (Fig. 4) and "Unimog" (Fig. 5)] were used. The area to be sprayed was measured out in such a manner as to permit the whole area to be treated in 3—5 days at the most. Several control groups succeeded in completely spraying their respective areas within three days. In other areas, however, it took 8—14 days to carry out the sprays, this being due to the unfavourable manner in which the area was divided up, unsettled weather and

difficulties in obtaining water. Experience has shown that it is not in every case possible to treat 100 hectares with one sprayer in a period of 3—5 days. In special cases spray districts have to be established consisting of only 75 hectares of beet fields since it is absolutely essential that spraying is carried out at the correct time, and preferably in less than three days. The power per unit surface of the type of sprayer used depends largely upon the supply of water. The water consumption is particularly large in cases where sprayers with a long spraying range are used and which require 400 l/ha with 400 g of "Systox" per hectare. Tank fillers designed to fill 100—150 litres per minute permit filling to be carried out within a relatively short time although it is essential that the growers arrange in good time for water to be made available on the peripheries of the fields storing it in clean drums normally used for holding liquid manure, this of course only being necessitated if there are no static sources of water in the immediate vicinity. Although these points might appear to be of minor importance, they are of great significance for the introduction of control measures in the field, since it is only by carrying out sprays at the right time, as already emphasized, that the greatest possible success can be realized and the economy of the control guaranteed.

In 1953 it was found that on the whole a single treatment of the beet fields was most adequate. Where the aphids occurred very early, however, two sprays were applied. By the end of July the aphid population had been more or less completely eradicated throughout the entire control area. In Figs. 6A, B, C graphs have been drawn illustrating typical aphid infestation *(Myzodes persicae)* together with the spray dates.

Fig. 5. Spigot-pipe type tractor-mounted sprayer ("Unimog") with 20 m spraying range. The spray pipes can be raised by means of pneumatic power lifters.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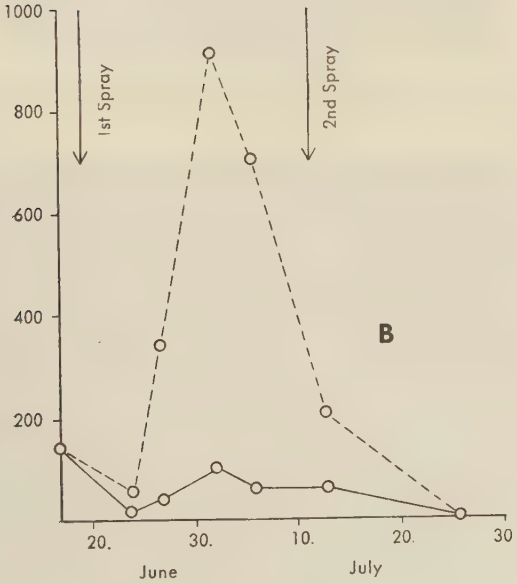
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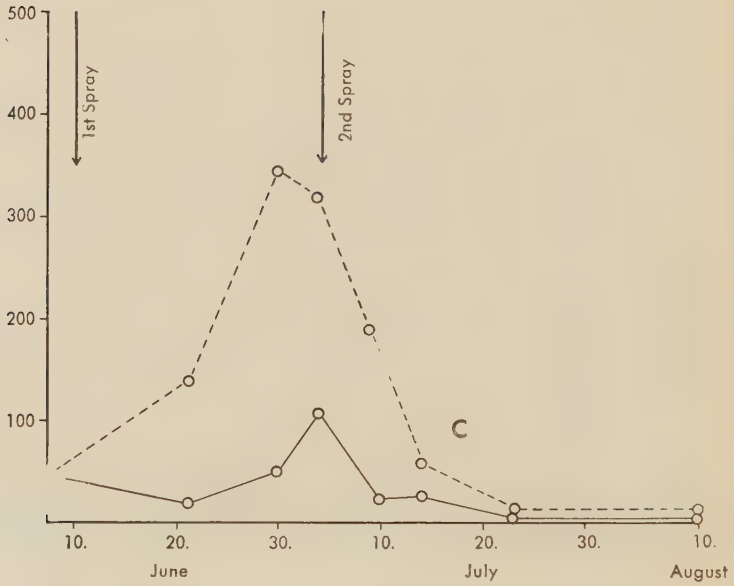

Fig. 6. Aphid infestation curves
A for Test No. 1 of Table 2
B for Test No. 11 of Table 2
C for Test No. 14 of Table 2
The figures on the ordinate are the number of aphids *(Myzodes persicae)* per 100 beet plants.
——— treated. — — — untreated.

V. Appraisal

a) Tests carried out in the area attached to the sugar factory in Soest

In order to check the extent of successes achieved by carrying out the control measures, evaluations were made on 22 fields containing a number of untreated check plots. In these tests large sprayers were used so that there would be no deviations from the methods employed in the control action. Due to the fact that the long working range of the sprayers necessitated the beet fields being split up into large plots, it was not possible to carry out replications. In order to obtain useful average values when determining the yields, 100 beets were lifted in each plot — in three lots of 33, 33 and 34 at three different places diagonally spaced over the test plot. The evaluations not only covered the determination of the beet and leaf yield but also the determination of sugar content, the crude protein content and the pure albumin content of the beets. Each of the lots of 100 beets lifted were used to determine the weight of the yield, with every 4th and 10th beet being used to determine the sugar content and the protein content respectively. The results of the evaluation are given in Table 2.

Treated and untreated plots of Test No. 2 of Table 2. In the foreground "Untreated". Photo: Dr. Korhammer.

Treated and untreated plots of Test No. 14 of Table 2. In the foreground "Untreated".

Table 2: Evaluation results of tests in

No.	Treatment	Sprayer Type	litres/ ha	Beet variety	Dates			Li
					Sowing	Spraying 1.	Spraying 2.	
1	1 × "Systox" (400 g/ha)	Platz tractor-mounted power sprayer ("Alldog")	400	Klein-wanzl. N	28. 3.	22. 6.	—	21
2	„	Platz tractor-mounted power sprayer ("Alldog")	400	Klein-wanzl. E	30. 3.	24. 6.	—	22
3	„	Fricke tractor-mounted power sprayer ("Alldog")	400	Klein-wanzl. N	15. 3.	30. 6.	—	24
4	„	Fricke trailer-type power sprayer	400	„	10. 4.	22. 6.	—	28
5	„	Holder trailer-type power sprayer	400	„	15. 3.	30. 6.	—	30
6	„	Fricke tractor-mounted power sprayer ("Unimog")	400	„	20. 3.	1. 7.	—	1
7	„	Fricke tractor-mounted power sprayer ("Alldog")	400	„	5. 4.	1. 7.	—	6
8	„	Fricke tractor-mounted power sprayer ("Unimog")	400	„	4. 4.	2. 7.	—	7
9	„	Platz trailer-type power sprayer	400	„	27. 3.	10. 6.	—	8
10	„	Fricke tractor-mounted power sprayer ("Unimog")	400	„	2. 4.	4. 7.	—	12
11	2 × "Systox" (400 g/ha)	Platz trailer-type power sprayer	400	„	20. 3.	19. 6.	11. 7.	16
12	„	Platz tractor-mounted power sprayer ("Alldog")	400	„	2. 4.	22. 6.	3. 7.	29
13	„	Blasator trailer-type power sprayer	400	„	28. 3.	20. 6.	15. 7.	6
14	„	Platz trailer-type power sprayer	400	„	27. 3.	10. 6.	4. 7.	8
15	1 × "Systox" (400 g/ha)	Fricke trailer-type power sprayer	400	Eckendorfer Gelbe	10. 4.	22. 6.	—	28
16	„	Platz trailer-type power sprayer	400	„	2. 4.	23. 6.	—	29
17	„	Fricke tractor-mounted power sprayer ("Alldog")	400	„	5. 4.	1. 7.	—	6
18	„	Fricke tractor-mounted power sprayer ("Alldog")	400	„	30. 3.	2. 7.	—	7
19	„	Fricke tractor-mounted power sprayer ("Unimog")	400	„	2. 4.	4. 7.	—	15

rea of the sugar factory at Soest

Relative eet yield ntreated (100 %) ated in %	Relative leaf yield untreated (100 %) treated in %	Relative sugar yield untreated (100 %) treated in %	Sugar content in %		Crude protein content (beets) in %		Pure albumin content (beets) in %	
			treated	untreated	treated	untreated	treated	untreated
102	93	102	17·9	17·8	—	—	—	—
116	81	127	17·9	16·1	1·25	1·44	0·63	0·63
108	115	105	16·4	16·8	—	—	—	—
99	109	104	17·9	17·0	1·25	0·96	0·75	0·59
116	134	117	18·0	17·9	1·25	1·06	0·63	0·63
124	112	127	16·2	15·9	2·19	1·75	0·75	0·69
98	119	98	17·8	17·8	0·94	1·06	0·56	0·63
123	141	123	18·8	18·8	1·31	1·19	0·69	0·69
107	92	115	16·8	15·6	1·00	1·44	0·38	0·69
108	94	104	17·2	17·6	1·19	1·19	0·69	0·56
115	106	119	17·4	16·8	1·75	1·69	0·75	0·75
137	131	142	18·0	17·4	1·19	1·00	0·63	0·56
138	125	143	18·4	17·8	1·31	1·19	0·69	0·69
119	94	126	16·6	15·6	1·38	1·44	0·63	0·69
105	114	—	—	—	—	—	—	—
116	109	—	—	—	—	—	—	—
128	112	—	—	—	—	—	—	—
117	106	—	—	—	—	—	—	—
99	88	—	—	—	—	—	—	—

b) Tests carried out in the area of the sugar factory at Lage

The tests carried out in this district which covered an area of 31·4 hectares served the purpose of establishing whether such measures are economic in districts where there is a medium-heavy infestation. The evaluation in this case was confined to determining the yields and sugar content. The results for tests

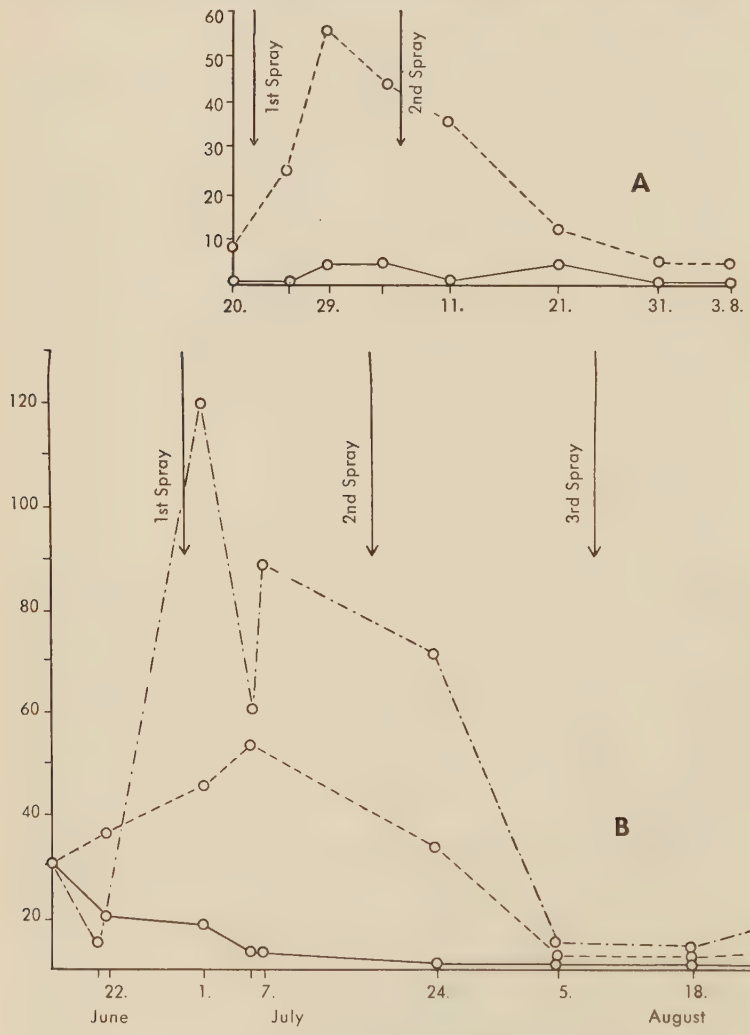

Fig. 7. Aphid infestation curves
A for Test No. 2 of Table 3
B for Test No. 4 of Table 3
The figures on the ordinate are the numbers of aphids (*Myzodes persicae* and *Doralis fabae)* per 100 beet leaves
——— treated, — — — untreated, . — . — . — untreated check plot.

Table 3. Evaluation results of tests in the area of the sugar factory at Lage/Lippe

No.	Treatment	Sprayer type	litres/ha.	Beet variety	Dates					Relative beet yield untreated (100 %)	Relative leaf yield untreated (100 %)	Relative sugar yield untreated (100 %)	Sugar content in %	
					Sowing	Spraying			Lifting					
						1.	2.	3.		Treated in %	Treated in %	Treated in %	Treated	Untreated
1	2 × "Systox" (400 g/ha)	Fricke tractor-mounted power sprayer ("Alldog")	400	Klein-wanzl. N	25. 4.	29.6.	17.7.	—	19.10.	107	103	108	15·7	15·55
2	2 × "Systox" (400 g/ha)	Blasator horse-drawn sprayer	400	„	11. 4.	22.6.	6.7.	—	8.10.	114	134	123	17·05	15·75
3	2 × "Systox" (400 g/ha)	Fricke tractor-mounted power sprayer ("Alldog")	400	„	4. 5.	22.6.	16.7.	—	15.10.	104	86	108	18·26	17·53
4	3 × "Systox" (400 g/ha)	Fricke tractor-mounted power sprayer ("Alldog")	400	„	25. 4.	29.6.	17.7.	8. 8.	19.10.	120	97	128	16·51	15·55
5	2 × "Systox" (400 g/ha), 2 × 5 kg/ha Bordeaux mixture (45 %)	Blasator horse-drawn sprayer	400	„	11. 4.	22.6.	6.7.	—	8.10.	123	140	134	17·2	15·75
6	3 × "Systox" (400 g/ha), 3 × 5 kg/ha Bordeaux mixture (45 %)	Fricke tractor-mounted power sprayer ("Alldog")	400	„	4. 5.	22.6.	16.7.	7. 8.	10. 9.	105	94	111	18·48	17·53
7	3 × "Systox" (400 g/ha), 3 × 5 kg/ha Bordeaux mixture (45 %)	Fricke tractor-mounted power sprayer ("Alldog")	400	„	18. 3.	20.6.	14.7.	7. 8.	29. 9.	105	114	103	16·7	16·5

1, 3, 4, 6 and 7 are the average values from four replications. In each plot an area of 100 square metres was lifted. The results of tests 2 and 5 were obtained from the yield of 100 beets, as described above. In tests 5, 6 and 7 the beets, as well as being sprayed with "Systox", were also treated with Bordeaux mixture (45 % Cu) at the rate of 5 kg/ha to control leaf spot *(Cercospora)*. The effect of the "Systox" sprays on the aphid population may be seen from the aphid infestation graphs (Figs. 7A and B). Counts were taken in accordance with the 100 leaf method both in the treated and untreated plots. Further check counts were also made in an adjoining, untreated sugar beet field which was located on that side of the test field away from the direction in which the wind was blowing. It was most interesting to note that the numbers of aphids counted in the adjoining field were much higher. It might be thought that there would be a certain influence exerted by the treated plots on the untreated plots when the latter are located very close to the same field.

The aphid infestation graphs show that the third spray, in certain cases only carried out for experimental reasons, could actually have been left out in 1953 since at the time of the spray the aphid population was already on the point of being completely dispersed, as is shown by the results obtained in the untreated check plots.

The evaluation results are given in Table 3. The large deviations in the leaf yield are a most striking feature of these results. The yield decreases in the untreated plots of tests 3, 4 and 6 may be attributed to the fact that as a result of transplantation or late sowing of the beets the yellow disease was able to occur relatively early on the first leaves formed on the untreated plants. Consequently these plants reacted by forming a large number of new leaves which as a rule leads to a reduction of the yield and the sugar content.

VI. Control successes and economy of the measures taken

a) In the control area of the sugar factory at Soest

Despite the fact that the occurrence of aphids and yellow disease in 1953 was not particularly heavy, it can just the same be said that the yield increases obtained in the treated plots when compared with those of the untreated plots (100 %) were most notable.

	1 spray	2 sprays
a) Sugar beets (Fig. 8)		
1. Beet yield	109 %	129 %
2. Leaf yield	105 %	116 %
3. Increase of sugar content as compared with the untreated plots	0·34 %	0·7 %
b) Fodder beets		
1. Beet yield	114 %	
2. Leaf yield	105 %	

It was established that particularly good yields were produced with "Ovana"-beets. Compared with the untreated plots there was a yield increase in beets amounting to 24 %. The results obtained with the "Ovana"-beets should not, however, be applied generally since these only represent an average value obtained in two tests.

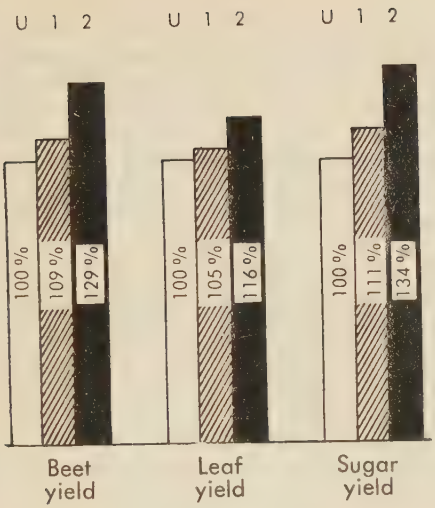

Fig. 8. Average yield increases in sugar beet tests with one (=1) and two (=2) "Systox" sprays of 400 g / ha as compared with untreated (=U). (Average of the tests in the heavily infested area.)

Should it appear unfavourable to introduce new control measures in the field during a year when the occurrence of a disease is by no means heavy, it may, however, be argued that the control successes achieved during such a year can throw a large amount of light on the economy of control methods. In calculating the economy of control measures 30 metric tons of beets per hectare and 32 metric tons of leaves per hectare were taken as a basis for the average yield of sugar beets in untreated fields, a harvest value which may be said to be too high rather than too low with respect to 1953. 100 kg of beets with 16 % sugar content were put down at DM 6·50, 100 kg of leaves at DM 2·00. 52 Pfg. were either deducted or added for each percent of sugar below or above 16 %. An average yield of 80 metric tons per hectare has been assumed for fodder beets. In Table 4 the yield increase expressed in DM per hectare has been compared with the spraying costs incurred by the growers.

As has already been mentioned, the fields were in most cases only sprayed once with "Systox" because of the low aphid infestation in 1953. Compared with

Table 4: Comparison of spray costs and yield increases (tests in area with heavy infestation).

Treatment	Spray costs in DM/ha	Yield increase in DM/ha	Profit in DM/ha
a. Sugar beets			
one spray	36·00	274·00	238·00
two sprays	72·00	827·00	755·00
b. Fodder beets			
one spray	36·00	224·00	188·00

the low costs incurred for spraying, the success achieved may be put down as good. The profits were approximately 6 times greater than the spraying costs. The tests in which by way of exception two sprays were carried out due to an early and heavy aphid infestation showed what yield increases may be generally expected in those years when there is a serious occurrence of the disease. The economy of the measures becomes apparent when it is necessary to carry out several sprays, in fact all the more so as the degree of yellow disease increases, since under these conditions the difference in yield between treated and untreated fields is most outstanding.

b) In the area of the sugar factory at Lage

In the tests where only "Systox" was applied, the yields of the treated plots as compared with the untreated plots (100 %) were as follows:

Sugar beets (Fig. 9)	2 sprays	3 sprays
1. beet yield	108 %	120 %
2. leaf yield	104 %	97 %
3. increase of sugar content	0·72 %	0·96 %

In Table 5 the spraying costs and yield increases are compared with each other.

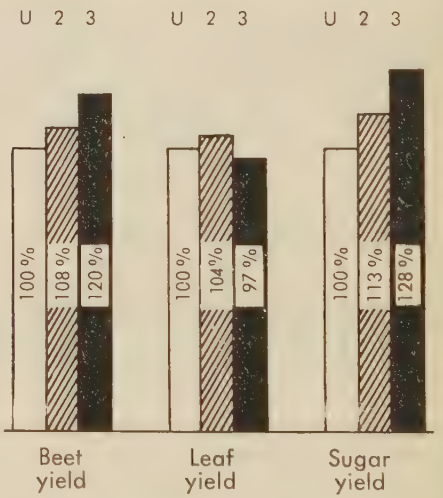

Fig. 9. Average yield increases of sugar beet plots sprayed twice (= 2) and three times (= 3) with 400 g "Systox" / ha as compared with untreated (= U). (Tests in area with medium-heavy infestation.)

Table 5: Comparison of spray costs and yield increases (tests in area with medium-heavy infestation).

Treatment	Spray costs in DM/ha	Yield increase in DM/ha	Profit in DM/ha
Sugar beets			
two sprays	72·00	331·96	259·96
three sprays	108·00	533·40	425·40

According to these figures it proved to be most economical to carry out control measures even in areas where there was only a medium infestation, in addition to which the condition of the leaves on treated beet plants was considerably improved.

VII. Summary of the most outstanding experiences gained

1. The method worked out by Steudel and Heiling to control yellow disease in beets by spraying virus-transmitting aphids with "Systox" proved to be most useful when done on a large scale even in a year when the occurrence of the disease was only slight.
2. It is most important that spraying on a large scale is carried out at the right time if success is to be ensured.
3. In order to fix the right dates for carrying out sprays it is most advisable to establish an aphid warning service. It is recommended that such a service be supervised by an official plant quarantine and pest control office.
4. The migration of aphids to the beet fields was continually interrupted in 1953 due to the bad weather prevailing at the time with the result that the numbers of aphids caught in aphid traps did not serve as a useful guide for fixing spraying dates that year.
5. Both the 100 beet plant method and the 100 beet leaf method proved useful in determining the aphid infestation in beet stocks. The 100 beet leaf method made counting easier and enabled a large number of counting stations to be set up. Spraying was started as soon as it was established that there were 30—50 *Myzodes persicae* infesting every 100 beet plants. When carrying out large scale operations, it would, however, be much safer to start spraying as soon as 20—30 *Myzodes persicae* are detected on every 100 plants.
6. Control groups should not be too large since it is most essential to spray the infested beet fields within a period of three days. It was found that dependent upon the division and location of the beet fields, 75—100 hectares (maximum) of beets can be sprayed in three days when using one of the sprayer types referred to earlier in this report. The daily capacity of the apparatus can be increased, should it be found necessary for the operators to work in two shifts.
7. As far as the ground conditions and division of the fields permit it, only apparatuses with a spraying range of at least 10 m should be used in order to maintain the power per unit surface and to avoid damaging the plants as much as possible. The use of sprayers with a range of 20 m — for the first time — proved to be a great advantage on level ground.
8. As a result of the precautionary measures being strictly complied with, there were no cases of persons or animals being poisoned by "Systox".
9. Despite the fact that the aphid occurrence was generally most weak, it can be said that the control was a great success. The yield increases from fields where early and heavy aphid infestations rendered it necessary to carry out two or three sprays were particularly high.
10. The control method proved in 1953 to be most economic in areas where there was a heavy and medium heavy infestation, in a year during which, generally speaking, the occurrence of yellow disease was relatively slight.

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"Systox", a Systemic Insecticide for Pineapple Mite Control

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Many newly set pineapple plants die from pineapple mite, *Dolichotetranychus floridanus* (Banks), infestations. Other infested plants remain small and produce very little or no fruit. Although this mite infests plants of all ages, it is a serious pest only on young ones. Nursery stock distributed or sold by nurserymen, or used by fruit producers, should be free of mites and other pests.

Control of the pineapple mite has not been entirely satisfactory to date. Fumigation of planting stock with two pounds of methyl bromide per 1,000 cubic feet, at 80° F, and normal atmospheric pressures, gave less than perfect control in various tests. Fumigation of planting stock with the same amount of methyl bromide at partial vacuum gave perfect mite control but killed some of the plants. Parathion, when used as recommended by Wolfenbarger and Spencer (1951) for control of pineapple mealybug, *Pseudococcus brevipes* (Ckll.), has not given satisfactory control of the pineapple mite.

Other miticidal chemicals were used as dips or sprays in various experiments for mite control. Aramite, azobenzene, D-N, EPN, Karathane, malathon, oil emulsions, Ovotran, parathion, selenium, sulfur and TEPP were tested at con-

centrations ordinarily used for mite control. Exposed mites were killed but those nearest the stalk between the tightly appressed leaves remained alive.Apparently all of these materials killed the mites with which they made contact. It was clear from these results that some method or miticidal material other than those used was needed for pineapple mite control.

"Systox" was used in the experiments herein reported. This material is one of the newer, organic, phosphatic pesticides, and acts systemically as discussed by Wilson (1951). A systemic pesticide is one that is absorbed by a plant, translocated within it and that kills pests on all parts of the plant. Thus this material offered another approach to the solution of the problem of pineapple mite control. "Systox" contains the diethoxythiophosphoric ester of 2-ethyl-mercaptoethanol as the active ingredient. Although selenium, an inorganic material, functions systemically also, it is such an extremely toxic material that it can be used only at very low concentrations. It was ineffective against the pineapple mite at the low concentrations tested.

"Systox" has been approved for use on cotton and certain ornamental plants. It has not been approved for use on pineapple plants, nor is it commercially available for such use. The results presented here are only of academic interest at present. They may be of practical value in pineapple production, provided "Systox" is approved for use on this plant.

Field Experiments

Two field experiments were conducted in cooperation with D. S. Radebaugh, Sebring, Florida. In one, the planting stock was dipped and set in regular beds in the field. In the other, small nursery plants were sprayed with the insecticide. The formulations of "Systox" used in these experiments contained three pounds of active ingredient per gallon, and the parathion formulation contained four pounds of active ingredient per gallon.

Dips were prepared containing one gallon, one-half gallon, and one and one-half cups of the "Systox", formulation per gallons of water. These were compared with one-half pint of the parathion formulation per 100 gallons of water. All plants were immersed in the dip, removed immediately, and set aside to drain and dry. The treated plants were placed in beds the day after they were dipped, along with untreated or check plants.

Plants from each treatment were examined for living mites 26, 96 and 145 days after treatment. The six lower leaves were removed from each plant examined. A summary of the results is given in Table 1.

Table 1: Pineapple mite control with "Systox" and Parathion dips.

Treatment and Amt./100 gals.	Days after treatment					
	26		96		145	
	No. plants examined	No. (percentage) plants infested	No. plants examined	No. (percentage) plants infested	No. plants examined	No. (percentage) plants infested
"Systox" 1 1/2 cups	24	0 (0%)	10	1 (10%)	10	1 (10%)
"Systox" 1/2 gal.	6	0 (0%)	10	0 (0%)	10	0 (0%)
"Systox" 1 gal.	6	0 (0%)	10	0 (0%)	10	3 (30%)
Parathion, 1/2 pt.	6	1 (17%)	10	2 (20%)	10	3 (30%)
Check	18	11 (61%)	10	7 (70%)	30	14 (47%)

Plants dipped in one-half and one gallon of "Systox" per 100 gallons of water were freed of mite infestations for three months. Some infested plants were found 145 days after treatments, but these consisted of only a few mites in each instance, and were considered likely to be reinfestations that came from an adjacent bed.

In the second experiment 1, 2, 4, and 8 pints of "Systox" per 100 gallons of water were sprayed on small plants in beds of nursery stock. All leaves and the soil about the plants were thoroughly wet. After thirty-three days, percentages of mite infested plants were 86, 93, 86, and 35, respectively, for each concentration of "Systox" sprayed plants. Examinations three months later showed that sprays of the three highest concentrations had provided better control than indicated by the earlier observations. More complete control ist needed than was obtained by these tests.

Laboratory Experiment

A laboratory experiment was conducted to compare localized applications of equal amounts of "Systox" with a "Systox" dip, with a parathion wettable sulfur dip, and an untreated check.

Pineapple mite infestations. Arrows point to infested areas which enlarge and coalesce to kill leaves and young plants.

It was determined that an average of 2·5 ml. of "Systox" dip (one quart per 100 gallons of water) adhered to each pineapple plant dipped. This amount of "Systox" diluted with an equal quantity of water was applied to freshly cut bases of the plants in one treatment, to the upper leaf surfaces in a second, and to the lower leaf surfaces in a third. After the fluid had dried, the plants were placed in a box and put aside.

The plants were examined 13 days after treatments for mites. Leaves were removed from each plant until a living mite was found or until the plants had been torn apart. A summary of the results is given in Table 2.

Table 2: Pineapple mite control with "Systox" and Parathion-wettable sulfur treatments.

Treatment	No. dead mites to 1st living one	Pctg. of plants infested
"Systox" dip	—	0
"Systox", base of plants	150:1	40
"Systox", on upper leaf surfaces	5:1	100
"Systox", on lower leaf surfaces	7:1	100
Parathion-w. sulfur dip.		
1/3 pt. + 10 lbs./100 gal.	7:1	100
Check	3:1	100

"Systox" dip was superior to all other treatments. Parathion plus wettable sulfur dip was not effective in reducing the percentage of infested plants. "Systox" placed on freshly cut bases of plants was more effective than the same amount placed on either the upper or lower leaf surfaces. This indicates that translocation occurred, since "Systox" placed at the base of plants killed mites on leaves which had not been treated previously.

Observations on Pineapple Mealybug

Plants treated with either "Systox" or parathion were free of the pineapple mealybug when examined, although some were infested at the time of treatment. All observations in connection with these experiments indicate that "Systox" is as effective as parathion for mealybug control.

"Systox" and its Residue in Fruit

Some "Systox" is a systemic pesticide and as such is translocated in the plant, one may question its use on food-crop plants. It should be clearly understood that "Systox" has not been approved for use on pineapples at this time.

Summary

Dipping pineapple planting stock in "Systox", at one quart or more per 100 gallons of water, gave complete control of the pineapple mite up to five months after treatment. Spraying or drenching plants in beds with "Systox" concentrations of one pint to one gallon of "Systox" per 100 gallons of water gave poor control or none at all. "Systox" dips were more effective than dips of parathion or parathion combined with wettable sulfur. This material has not been approved for use on pineapple plants.

Precautions

"Systox", an organic phosphatic insecticide, is toxic to man and other animals. Caution must be exercised by those using. Avoid contact with the insecticide or wetting of skin and clothing. Wear rubber gloves, aprons, or other protection during the dipping process. Approved masks are recommended.

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Investigations into the Plant Physiological Efficacy of the Systemic Insecticide "Systox"

by Richard W. Waeckers

During experimental work carried out in 1935 and 1936 at the laboratories of the former I.G. Farbenindustrie A.G. as it was then known, fluorine compounds were discovered for the first time which are absorbed by plants and once inside the plant maintain their insecticidal efficacy. From this stage, further progress made during the years that followed led to the insecticidally effective phosphoric acid esters and finally to the preparation "E 1059" (Lit.). 16 years after the discovery of the first systemically effective preparation, Messrs. Farbenfabriken Bayer introduced "E 1059" under the name of "Systox" on the German market as the first systemically effective insecticide.

Such a development of systemic insecticides naturally led to an abundance of questions and problems being raised for which previously very little interest had been shown in pest control circles. More and more importance is being attached to the interrelations between the plants and the applied preparation. The plant which in the past has always been regarded in normal cases as a passive factor in its capacity as a carrier of an insecticidal preparation has now become a most active factor in the application of systemically effective insecticides. On the one hand the physiological and morphological conditions of the plant determine the extent and nature of the penetration of the preparation into the plant tissue, the translocation, the stability and the storage of the preparation in the plant. On the other hand the molecule of the active ingredient which has penetrated into the tissue and which is physiologically very active in the animal organism, is capable of influencing the metabolic physiological processes in the plant (Lit.). Therefore the possibility of applying a systemic preparation depends upon a good cellular physiological compatibility to a far greater extent than was previously the case with the usual types of insecticides employed in the past. Even cases where in field tests it is hardly possible to detect damage should give rise to thought.

What it means to expect good plant compatibility from a systemically effective preparation even when applied several times is best judged when one considers how very sensitively plants react for example to the weakest concentrations of arsenious acid or sulphur dioxide.

"Systox" has been tested most thoroughly both in Germany and abroad for its plant compatibility among the most various useful and ornamental plants. Apart from observations showing a certain sensitivity of the apple varieties McIntosh, Melba and Guldborg in certain stages of their seasonal development, there is no reliable information available that the preparation acts phytotoxically when applied in the usual concentrations.

During field tests carried out with the systemically effective phosphoric acid esters, in particular during outdoor tests with "Systox", certain effects occasionally occurred which apparently cannot be attributed solely to the insecticidal efficacy of the preparation (Lit.). The appearance of the treated plants, the vigorous growth and the yields, even where damage had been caused although hardly perceptible, had improved so considerably in comparison with the checks that it was thought the plant metabolism had been positively influenced by

the preparation. It therefore appeared commendable to clarify whether the preparation has any positive subsidiary effects upon the plant and what damages to the plant may be expected should too heavy a dose be applied. Along with these problems, the question about the stability or a possible transposition of the two "Systox" isomers in the plant became more and more important (Lit.).

In order to provide a few contributions to the solution of these questions, a number of investigations were carried out in 1952 and 1953 at the experimental farm of Messrs. Farbenfabriken Bayer in Höfchen, in co-operation with the Botanical Institute of the University of Marburg. A few provisional results of these tests are given in the following.

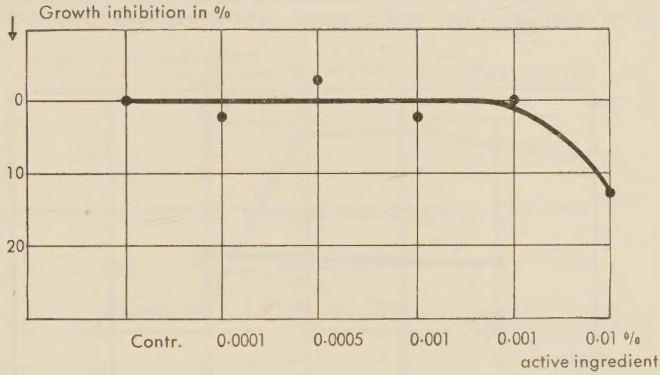

Fig. 1: Growth inhibition of the cress root in "Systox" emulsions. Ordinate: Growth inhibition in percent of additional growth of water check (O-line). - Abscissa: concentration of active ingredient.

Since no very strong positive or negative effects were to be expected as based on past experience, the manometric method was used for measurements of metabolism. For methodical reasons, it appeared favourable to use objects with simple organisms. The pure active ingredient of the commercial preparation, the emulsifier of the commercial preparation and the pure isomers, from which the active ingredient is made up, were tested. In view of the fact that the preparation is used as a watering agent, it was also decided to observe at the same time the behaviour of the roots.

Occasionally an action by the preparations tested on the physiological processes of the selected test plants becomes apparent as a result of inhibition or promotion of the extensible growth (Lit.). In these investigations, M o e w u s ' s method (Lit.) was also used to check the influence of "Systox" upon the extensible growth of cress roots. Comparative results are arrived at, just as in a corresponding test of "E 605" (Lit.). Growth is not inhibited until an active ingredient concentration of approx. 0·01 % is used (= 0·02 % commercial preparation). Growth is not promoted by the lower concentrations.

Since the preparation is recommended for use in field work as a watering agent in concentrations of up to 0·05 %, investigations had to be carried out to determine the concentration of the applied "Systox" when it reaches the roots. Radioactive marked preparation was poured onto soil pillars 2, 4, 6 and 14 cm high. Sand, light loam and a strongly humous soil were tested. It was found that on passing through the soil samples the concentration of the "Systox"

solutions decreased greatly. On using a 0·05 % solution, the concentration of the applied solution decreased by approx. one power of ten on passing through a 4 cm layer of humous soil or a 6 cm layer of loam or an 8 cm layer of sand. The concentration which in the cress test had an inhibiting effect decreases in each case after passing through only 2—3 cm. The respiration of various roots (cress, tradescantia, sugar beets) was measured under the influence of the preparation. During the absorption of "Systox" the roots showed no appreciable change in the respiration until concentrations which cause sublethal damage were applied, amounting to 0·15 % of the commercial preparation.

To clear up the question of a possible influence of the active ingredient upon photosynthesis, the unicellular green alga *Ankistrodesmus falcatus* and the leaves of the Canadian water weed, *Helodea canadensis*, were selected as

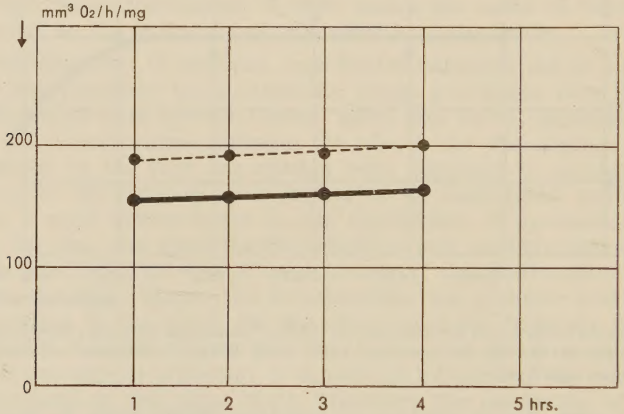

Fig. 2: Photosynthesis of *Ankistrodesmus falcatus* in strong light (Receptacle method). — Straight line: Algae in 0·007 % "Systox" (P=S isomer without emulsifier). — Dash line: Algae in "Systox"-free nutrient solution.

"tests plants". It was not until both isomers were used in a concentration of 0·0065 % active ingredient (0·013 % commercial preparation) that there was a reversible depression of the photosynthesis to approx. 20 %.

These values cannot of course be applied quantitatively to cultivated plants. Of the concentration sprayed in the field, which is in this range, only that concentration is physiologically effective in the plant which is present in the leaf following the penetration of the preparation. The results obtained by Tietz (Lit.) show that a large percentage of the active ingredient evaporates after application. It is also probable that a part of the active ingredient is also retained in the cuticle. The active ingredient which actually penetrates into the interior of the leaf is further propagated as the result of translocation. The concentration present in the interior of the leaf is considerably reduced when compared with the concentration of the spray wash.

Results obtained with *Vicia faba* (Lit.) show that with this plant there is a possibility of a weakly physiological disturbance occurring at the earliest after three sprays of a 0·1 % emulsion. The effect, however, is so slight that with this concentration it cannot be determined statistically with an adequate degree of reliability.

Using the same test plants (*Ankistrodesmus, Chlorella,* and *Helodea),* the oxygen absorption was also examined to represent the intensity of respiration during the action of the preparation. Concentrations of 0·0001 % and 0.01 % of the pure P = S and P = O isomers were used (concentrations above 0·007 % together with emulsifier).

Whereas the solution and emulsion of the pure P = O isomers produced no appreciable change in the intensity of O_2 absorption, there was, however, a noticeable effect with solutions and emulsions of the pure P = S isomer above a concentration of 0·005 % active ingredient. The O_2 absorption of algae in a 0·006 % solution increased by 15—20 %. In an emulsion containing 0·01 % active ingredient, the oxygen absorption increased by almost 100 %.

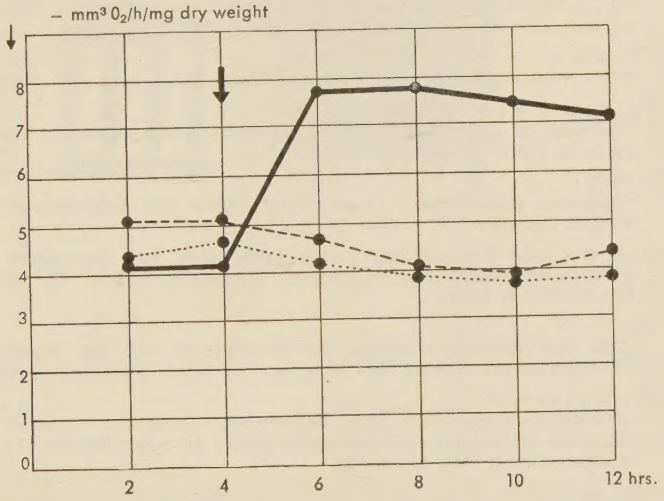

Fig. 3: Respiration of *Ankistrodesmus falcatus* in nutrient solution (receptacle method). After the 4th hour addition of: 0·5ml nutrient solution without "Systox" (/4·5ml algae suspension): dotted line; 0·5 ml of a 0·2% emulsion of "Systox" P=O isomer (/4·5 ml algae suspension): dash line; 0·5 ml of a 0·2% emulsion of "Systox" P=S isomer (/4·5 ml algae suspension): straight line.

Like the photosynthesis inhibition, this increase in respiration is also reversible. Just as was shown by the investigations carried out with roots of various tall plants, this result cannot be applied generally. It is possible that the differences in the physiological efficacy of the two isomers are connected with the greatly varying water solubility (Lit.) of the two substances.

It is intended to establish whether this effect can be utilized to check more closely the stability or instability of the isomers in the green plants.

Tests carried out with two systemic insecticides on the basis of "Ompa" or "Schradan" produced comparative results. Even here, apart from a certain number of disturbances when high doses were used, there was no indication of a possible influence upon the plant metabolism in the lower concentrations. A detailed report will be given later.

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